



THURBER ENGINEERING LTD.

**CALAMITY CREEK SLOPE FAILURE INVESTIGATION
HIGHWAY 11, 2.9 KM NORTH OF HWY 65 JUNCTION
NEW LISKEARD, ONTARIO
5018-E-0010, WORK ITEMS #7 AND #11**

G.W.P. NO. 5159-12-00

Geocres Number: 31M-133

Report

to

Ontario Ministry of Transportation

**Latitude: 47.555742°
Longitude: -79.674656°**

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from a preliminary desktop study and subsequent foundation/geotechnical investigation for the Calamity Creek Southwest Slope Failure located adjacent to Highway 11, approximately 2.9 km north of Highway 65 near New Liskeard, Ontario.

The purpose of this investigation was to supplement the information on subsurface conditions identified in the desktop study and based on the data obtained, to provide a borehole location plan, an instrumentation monitoring plan, records of boreholes, stratigraphic profile, laboratory test results, a written description of the subsurface conditions, and results of the periodic slope monitoring.

Thurber Engineering Ltd. (Thurber) was retained by the Ontario Ministry of Transportation (MTO) to provide foundation/geotechnical engineering services for this project. This work is being carried out under assignment number 5018-E-0010, Work Order Number 7 and Work Order Number 11.

2. SITE DESCRIPTION AND BACKGROUND

The slope failure addressed in this report is located within the Calamity Creek valley (sometimes referred to the Calamity Gulch in historical documents). The failure is located on the south valley slope (i.e., the north facing slope) approximately 60 to 120 m west of Highway 11 and 300 m north of Concession Road 5 (Tobler's Road). The general location of the site is shown on the Key Plan inset on Drawing 1 in Appendix A.



Upstream of the failure, the valley is infilled with the Highway 11 embankment. Calamity Creek passes beneath the embankment within twin culverts (at about Station 17+645), which were recently installed by trenchless methods as part of a design-build assignment (DB 2017-5003). The culvert installation work was completed between September and October 2020. It is noted that two relatively shallow slope failures of temporary cut slopes occurred on the north facing slopes (one failure on the east side of the highway and one failure on the west side of the highway immediately adjacent to the slope failure currently under investigation) during April 2019, as documented by a Golder letter report dated May 3, 2019. It is understood that these previous slope failures were reinstated with granular fill during construction.

The slope failure under investigation occurred post-construction and was initially observed on November 9, 2020. The failure was visually monitored by others on a regular basis during the months of November and December 2020 prior to Thurber's involvement. The results of that initial monitoring are provided in Appendix G of this report for reference.

Thurber carried out a site reconnaissance on December 4 and 5, 2020 to visually inspect the slope failure and subsequently carried out a geotechnical investigation in January of 2021 that included the installation of slope inclinometers, vibrating wire piezometers (VWPs), and survey monitoring pins. A monitoring program has been on-going since that time, the results of which are presented in this report.

The new culvert to the east of the failure consists of twin 2133 mm diameter precast concrete pipes with a total length of approximately 210 m. The culvert alignment is generally oriented northeast-southwest with the flow through the culvert toward the southwest; however, for project purposes the culvert will be described as oriented east-west and the slope failure will be described as oriented north-south herein. The invert elevations at the upstream inlet and downstream outlet, as indicated on the design drawings, are approximately 196.8 m and 194.2 m, respectively.

At the location of the culvert, Highway 11 is a paved two-lane highway with guiderails on either side. The elevation of the road surface is approximately 213 m. The culvert is located below a high fill embankment up to 15 m in height. The highway embankment is up to 12 m thick with slopes ranging from approximately 2H:1V to 4H:1V, with localized areas that are steeper than 2H:1V. The area outside of the valley, referred to as the "tableland", is generally flat with a few residential houses and agricultural land.

Further details on the site are presented in the Site Reconnaissance discussion, Section 3.2 below.



3. DESKTOP REVIEW AND SITE RECONNAISSANCE

3.1 Existing Information

Prior to the field investigation Thurber carried out a desktop review of existing information, which included the following documents provided by the MTO.

- Report by Shaheen & Peaker Limited, titled “Exploratory Boreholes, W.P. 147-98-00, Agreement No. PO5005A000062”, dated December 14, 1999 (Project No. SP3012) [Geocres No. 31M-66].
- Report by Terraprobe to MMM Group Limited, titled “Preliminary Foundation Investigation and Design Report, Calamity Creek Culvert, Highway 11, Assignment No. 5013-E-0018, Ministry of Transportation, Ontario, G.W.P. No. 5159-12-00, Site 47-273C”, dated April 11, 2016 (File No. 11-14-4066) [Geocres No. 31M-109].
- Report by Thurber Engineering Ltd. to MMM Group Limited, titled “Foundation Investigation and Design Report, Highway 11 Calamity Creek Culvert Replacement, 2.9 km North of North Junction of Hwy 11 and Hwy 65, Site No.: 47-273C, GWP No.: 5159-12-00”, dated June 2017 (File No. 19-5161-208) [Geocres No. 31M-119].
- Report by EXP Services Inc. to Ontario Ministry of Transportation, titled “Foundation Investigation Report, Supplementary Foundation Investigation for RFP Stage of DB Calamity Creek, Culvert Replacement, Highway 11, New Liskeard Area, Ontario, Agreement No. 5015-E-0007, Assignment No. 8, GWP 5159-12-00”, dated January 9, 2018 (Project No. ADM-00233185-I0) [Geocres No. 31M-121].
- Report by Golder Associates Ltd. to Construction Demathieu & Bard Inc., titled “Foundation Investigation and Design Report, Calamity Creek Culvert Replacement, Site No. 47-273/C, Highway 11, Contract Number DB-2017-5003, Northeastern Region”, dated August 15, 2018 (Project No. 1789567-1).
- Site photographs (pre and post failure).
- Design drawings prepared by the design-build contractor for the Calamity Creek culverts (Demathieu Bard Construction).
- Daily slope failure reports prepared by LEA Consulting dated November 30 through December 7, 2020.
- A technical memo prepared by LGL Limited dated November 18, 2020,
- Two geotechnical letter reports addressing separate slope failures during construction prepared by Golder dated May 3 and May 31, 2019.
- A Landscape Plan prepared by Golder dated September 29, 2020.



The factual information from the GEOCRETS reports (e.g., borehole plans, boreholes records and laboratory testing results) are provided in Appendix F.

It must be recognized that the service providers that produced the historical FIDR reports are solely responsible for the accuracy and quality of the subsurface information presented in their respective reports and that conditions, particularly near ground surface, may have changed subsequent to the investigations.

3.2 Site Reconnaissance – December 2020

A site reconnaissance visit was carried out by Thurber on December 4 and 5, 2020. The project site was visited and visible geological/geotechnical features were documented and assessed with respect to the slope failure.

Based on site observations, the slope failure was measured to be approximately 20 m wide at the head scarp and 36 m wide at the toe. Multiple scarps and slump blocks were observed within the failure, consistent with a retrogressive landslide. The depth of the failure that was visible was assessed to be approximately 3 to 5 m; however, the bottom of the failure was filled with slide debris and therefore the full depth of the slide could not be confirmed. The soil within the slide debris generally consisted of grey varved clay and silt. The total vertical height of the slope failure is in the range of 22 to 24 m from the creek floor to the crest of the headscarp.

The average slope angle through the middle of the failure at the time of the site visit was approximately 17.9 degrees from horizontal (3.1H:1V); however, locally steeper sections were observed within the failure scar, most notably a section on the west side of the slide with a slope angle of approximately 40 degrees (1.2H:1V). The opposite side of the valley (i.e., the northwest slope), which appears to be stable, currently has a slope angle of approximately 16.5 degrees (3.4H:1V).

The approximately 0.5 to 1.0 m wide creek at the base of the slope has cut a channel through the slide debris to create a new stream channel.

The house located directly behind the failure is approximately 55 m back from the current head scarp. At its closest point, Highway 11 is located approximately 60 m away from the head scarp; however, in the direction of the failure (southeast), the highway is located approximately 75 m back from the head scarp.

No tension cracks were observed above the highest point of the existing head scarp; however, tension cracks were observed to the sides of the head scarp both to the west and east.

Three other recent slope failures were observed downstream (to the west) within the Calamity Creek valley. All three failures are not readily visible in aerial images taken in August 2019. Older historical landslides (i.e., decades old) were also evident during the site visit and several



landslides have also been documented by others dating back to the early 1900's. The history of slope instability in this valley suggests that the native slopes are young and only marginally stable.

Select photographs of the site are included in Appendix D.

3.3 Aerial Photograph Review

Aerial photographs from the years 1951, 1963, 1971, 1980 and 1994 were obtained from the National Air Photo Library of Natural Resources Canada and viewed to assess the terrain around the slope failure. Zoomed-in versions of the air photos are included in Appendix D. Based on a review of the air photos the following comments are provided:

- A large landslide occurred immediately west (downstream) of the existing slope failure on the south (north-facing slope) sometime between 1963 and 1971. The landslide is not evident in the 1963 air photo, which shows an over-steepened slope and a relatively straight creek alignment. Subsequent air photos, including present Google Earth satellite imagery, show the presence of large semi-circular landslide scarp as well as a significantly altered creek alignment. The width of the previous landslide is approximately 100 to 150 m wide and 60 to 80 m long. Based on observations made during the site reconnaissance (see “bowl-like topography” of historic landslide in the photos in Appendix D), this previous failure is likely the result of a deep-seated global slope stability failure.
- The existing slope failure currently under investigation is located at the eastern extent of the large historical landslide described above and appears to be located, at least partially, inside the failure scarp of the previous landslide. It is considered possible that the failed material at the base of the new landslide consists of previous failed soil that would have had a lower residual shear strength.
- Several smaller scale slope failures were observed in the creek valley on the historical air photos.

4. SITE INVESTIGATION AND INSTRUMENTATION INSTALLATION

The investigation and field testing program was carried out between January 11 and January 16, 2021. The field investigation consisted of advancing five boreholes identified as INC 21-1, VWP 21-2, MW 21-3, INC 21-4 and VWP 21-5. In addition, the field investigation included the installation of 23 survey pins (identified as S6 through S28) and 6 T-bar survey pins (identified as T1 through T6).

A summary of the field investigation work is summarized in Table 4-1 below.

Table 4-1 Description of Current Investigation and Monitoring Installations

Borehole No.	Description
INC 21-1	Continuous field vanes were completed in the varved clay below approximately 3.4 m depth, and standard penetration tests (SPT) were carried out within the underlying glacial till. The borehole was subsequently advanced approximately 2.4 m into bedrock and a slope inclinometer casing was installed within the full depth of the borehole.
VWP 21-2	Soil samples were acquired using SPT in surficial materials and a piston sampler in the varved clay. SPTs were carried out within the glacial till. The borehole was terminated upon practical refusal within the glacial till. A Vibrating Wire Piezometer (VWP) was installed in the clay at an approximate elevation of 190.2 m (26.2 m depth).
MW 21-3	This borehole was advanced for the purposes of installing a monitoring well. Sampling was only carried out near the bottom of the borehole to confirm that the clay had been fully penetrated. The monitoring well was screened across the glacial till with the base of the well at an approximate elevation of 184.0 m (32.1 m depth).
INC 21-4	Soil samples were collected at regular intervals of depth throughout the entire thickness of the overburden. The borehole was subsequently advanced approximately 2.5 m into bedrock and a slope inclinometer casing was installed within the full depth of the borehole.
VWP 21-5	This borehole was advanced for the purposes of installing a VWP. Sampling was only carried out near the bottom of the borehole. The VWP was installed in the clay at an approximate elevation of 191.1 m (25.1 m depth).
S6 through S28	Each survey pin consisted of a 38 mm diameter PVC pipe grouted into an open borehole that was advanced to approximately 3 m depth without sampling.
T1 through T6	Each T-bar survey pin consisted of a 1.8 m long steel T-bar driven into the ground as deep as possible with a sledge hammer.

The boreholes that were drilled for the installation of slope inclinometers, vibrating wire piezometers, and the monitoring well were advanced by wash-boring techniques using a track-mounted CME 55 drill rig. The boreholes that were drilled for the installation of the survey pins (S6 through S28) were advanced with a portable drill rig using solid-stem augers.

Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations. A summary of the coordinates, ground surface elevations and termination depths for each of the boreholes advanced for the current investigation (excluding survey pins) is summarized in Table 4-2 below.

Table 4-2 Summary of Boreholes – Current Investigation

Borehole No.	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
INC 21-1	5 269 209.1	404 472.3	216.2	34.2
VWP 21-2	5 269 211.8	404 478.8	216.4	32.2
MW 21-3	5 269 197.8	404 466.3	216.1	32.1
INC 21-4	5 269 201.5	404 473.9	216.2	34.2
VWP 21-5	5 269 205.0	404 480.8	216.2	28.7

In Boreholes VWP 21-2, MW 21-3, INC 21-4 and VWP 21-5, soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) following ASTM D1586. Shelby tube samples of the clay were also collected with a piston sampler in Borehole VWP21-2. Field vane testing was carried out in the cohesive deposits in Borehole INC 21-1 at selected depths using an MTO N vane. Boreholes INC 21-1 and INC 21-4 were advanced into bedrock using rotary diamond drilling techniques while collecting HQ sized bedrock core. Boreholes VWP 21-2 and MW 21-3 were advanced until achieving practical refusal on very dense till or bedrock. Borehole VWP 21-5 was advanced to a depth of 28.7 m, where a VWP was installed in the clay.

The drilling and sampling operations were supervised on a full-time basis by an experienced member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

Slope inclinometers were installed in Boreholes INC 21-1 and INC 21-4 to allow for subsequent slope monitoring and VWPs were installed in Boreholes VWP 21-2 and VWP 21-5 to allow for measurements of the porewater pressure after completion of drilling. A 50 mm monitoring well was installed in Borehole MW 21-3 to allow for measurement of the groundwater level. The monitoring well installation details are illustrated on the Record of Borehole sheets provided in Appendix B. All of the boreholes/instrumentation were backfilled with a low-permeability bentonite-cement grout mix in accordance with Ontario MOE Regulation 903 as amended.

5. LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained split-spoon and Shelby tube samples. Of the collected Shelby tube samples of the varved clay deposit, seven samples were submitted for unconfined compressive strength testing, two samples were submitted for direct simple shear testing (consolidated-drained conditions), and two samples were submitted for triaxial testing (consolidated-undrained



conditions). Grain size distribution and Atterberg limits testing was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

6. SUBSURFACE CONDITIONS

Details of the soil stratigraphy encountered during the current investigation are presented on the Record of Borehole sheets included in Appendix B. Detailed descriptions of the previous field investigation methodologies and results are presented in the individual reports listed in Section 3.1. Details of the soil stratigraphy encountered in Boreholes 16-1, 16-2 (Geocres No. 31M-119) and BH6 (Geocres No. 31M-109) during the previous investigations are included in the following sections and presented on the Record of Borehole sheets provided in Appendix F. The laboratory test results from the previous investigations are also provided in Appendix F. The Record of Borehole sheets for the previous boreholes that are not discussed below are also provided in Appendix F. It must be recognized that the shallow subsurface conditions presented on the previous borehole records have likely changed as a result of the recent culvert construction.

A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. It is noted that the boreholes for the investigation were all located outside the footprint of the slope failure and therefore may not represent the conditions within the limits of the slope failure.

In general terms, the subsurface conditions at the location of the slope failure consist of a thin surficial layer of clayey organic silt overlaying an approximately 30 m thick deposit of varved clay to varved clay and silt, which is underlain by a thin deposit of glacial till that in turn overlies sandstone bedrock. A summary of the subsurface information from the current investigation is presented in the following sections. Information from previous investigations that is considered pertinent to the current investigation is also included in the discussion below.

Soil descriptions for the 2021 boreholes are in accordance with the Unified Soil Classification System, ASTM D2487, as modified by current MTO standards for cohesionless soils. Soil classifications from previous investigations may not reflect the same terminology.

6.1 Topsoil and Clayey Organic Silt

Surficial topsoil/clayey organic silt was encountered at surface in all of the boreholes. The topsoil/clayey organic silt ranged in thickness from approximately 0.1 to 0.6 m.

SPT N values in this material ranged from 4 to 6 blows, indicating a very loose to loose relative density. The moisture content on tested samples typically ranged from 53 to 70%.

6.2 Varved Clay (CH to CI to CL)

A thick deposit of glaciolacustrine varved clay to varved clay and silt (hereafter referred to as varved clay) was encountered beneath the surficial topsoil/clayey organic silt in all of the boreholes. The upper portion of the deposit has been weathered to a grey brown colour with evidence of fissuring. At the table land level (i.e., excluding Boreholes 16-1, 16-2 and BH6 that are located within the valley), the weathered varved clay was approximately 3.2 m thick with a bottom elevation ranging from approximately 212.3 to 212.6 m. SPT tests conducted in the weathered varved clay gave N-values ranging from 1 to 6 blows.

Beneath the depth of weathering, the varved clay is saturated and grey in colour. Where fully penetrated, the grey varved clay extended to depths ranging from approximately 7.8 to 31.1 m below the ground surface (elevations from 185.0 to 186.5 m). SPT tests conducted in the grey varved clay gave N-values ranging from weight of hammer to 4 blows. Field vane testing conducted in the grey varved clay gave undrained shear strength (s_u) values generally ranging from approximately 35 to 85 KPa, indicating a firm to stiff consistency. The lowest shear strengths were generally encountered between elevations 204 and 211 m, where the s_u values are generally in the range of 35 to 45 kPa. The stiffness of the deposit generally increases above and below these elevations. Remolded vane testing indicates that the sensitivity of the deposit generally ranges from approximately 2 to greater than 10 (low to medium sensitivity).

Moisture contents in the varved clay ranged from 22 to 63%. Gradation analyses were completed on 12 samples of this deposit (five from the current investigation). The grain size distribution curves for the five samples from the current investigation are included on Figure C1 in Appendix C. All of the test results are summarized in Table 6-1 below and the results are presented on the corresponding Record of Borehole sheets in Appendix B and Appendix F for the current investigation and previous investigations, respectively. It is noted that these test results represent composite samples of the clay and silt varves that are both present within the deposit. The varves were considered too thin to separate and test individually.

Table 6-1: Summary of Gradation Test Results – Clay

Soil Particle	Percentage (%)
Gravel	0
Sand	0 – 1
Silt	19 – 69
Clay	30 – 81

Atterberg limits testing was completed on 13 samples of the varved clay (six from the current investigation). The results are summarized in Table 6-2 below and the tests from the current investigation are summarized on Figure C2 in Appendix C. The results are presented on the corresponding Record of Borehole sheets in Appendix B and Appendix F for the current and previous investigations, respectively. It is noted that these test results represent composite samples of the clay and silt varves that are both present within the deposit. The varves were considered too thin to separate and test individually.

Table 6-2: Summary of Atterberg Limits Test Results – Clay

Parameter	Value
Plastic Limit	19 – 26
Liquid Limit	28 – 70
Plasticity Index	9 – 45

The results of the testing indicates that the varved clay ranges from low plasticity (CL) to high plasticity (CH).

Unconfined compressive strength tests were carried out on seven samples from Borehole VWP 21-2. The results of the testing are provided in Appendix C and are summarized in

Table 6-3 below.

Table 6-3: Unconfined Compressive Test Results

Sample ID	Sample Depth (m)	Unconfined Compressive Strength (kPa)	Undrained Shear Strength (kPa)	Strain at Failure (%)
VWP 21-2 TW3	4.6 – 5.2	57	29	7.4
VWP 21-2 TW6	6.9 – 7.5	41	20	3.8
VWP 21-2 TW7	7.6 – 8.2	45	23	11.3
VWP 21-2 TW8	8.4 – 9.0	59	29	4.1
VWP 21-2 TW11A	12.2 – 12.5	30	15	3.7
VWP 21-2 TW11B	12.5 – 12.8	48	24	2.1
VWP21-2 TW12	13.7 – 14.3	47	24	3.1

Direct shear testing was completed on two samples of the varved clay in Borehole VWP 21-2. The results of the testing are provided in Appendix C, and are summarized in Table 6-4 below.

Table 6-4: Direct Shear Test Results

Sample ID	Sample Depth (m)	Friction Angle (°)	Cohesion (kPa)
VWP 21-2 TW5	6.1 – 6.7	26	0
VWP 21-2 TW9	9.1 – 9.8	26	0

Consolidated undrained triaxial compression testing was also completed on two samples of the varved clay (VWP 21-2 TW4 and TW9). The results of the triaxial testing are provided in Appendix C.

Table 6-5: Consolidated Undrained Triaxial Test Results

Sample ID	Sample Depth (m)	Effective Stress Friction Angle (°)	Effective Stress Cohesion (kPa)
VWP 21-2 TW4	5.3 – 5.9	35	0
VWP 21-2 TW9	9.1 – 9.8	30	20

6.3 Glacial Till – Silty Clay (CL-ML)

A thin deposit of till consisting of silty clay, some sand and gravel to clayey sand with gravel was encountered below the varved clay in all Boreholes except VWP 21-5 (which did not fully penetrate the varved clay) and BH6. Where encountered, the till ranged from approximately 0.7 to 1.7 m thick with an underside elevation ranging from approximately 184.0 m to 185.8 m.

SPT N values in this material that did not refuse on the underlying bedrock ranged from 4 to 9 blows, indicating a loose relative density.

The moisture content on the tested till samples ranged from 5 to 28%. Gradation analyses were completed on three samples of this deposit (one from the current investigation). The grain size distribution curve for the sample from the current investigation is included on Figure C3 in Appendix C. All of the test results are summarized in Table 6-5 below and the results are presented on the corresponding Record of Borehole sheets in Appendix B and Appendix F for the current investigation and previous investigation, respectively.

Table 6-5: Summary of Gradation Test Results – Till

Soil Particle	Percentage (%)	
Gravel	3 – 24	
Sand	5 – 41	
Silt	39 – 92	28 – 69
Clay		17 – 23

Glacial tills inherently contain cobbles and boulders.

6.4 Bedrock

Boreholes INC 21-1 and INC 21-4 from the current investigation were advanced into the bedrock by coring. The bedrock encountered is generally described as fresh, thinly to medium bedded, fine to coarse grained, strong to very strong grey sandstone with occasional vugs. Rock Quality Designation (RQD) values generally range between 31 and 100%, indicating fair to excellent quality rock. Photographs of the bedrock core are presented in Appendix C.

The bedrock surface depths and elevations encountered in the current and previous boreholes are summarized in the following table.

Table 6-6: Summary of Bedrock Surface Depths/Elevations

Borehole	Bedrock Surface	
	Depth (mbgs)	Elevation (m)
INC 21-1	31.8*	184.4
VWP 21-2	32.2 ^{ref}	184.2
MW 21-3	32.1 ^{ref}	184.0
INC 21-4	31.7*	184.5
BH6	12.1*	185.6
16-1	8.8 ^{ref}	185.5
16-2	14.7 ^{ref}	185.8

Notes: *Bedrock proven by coring

^{ref} Suspected bedrock surface based on sampler refusal

6.5 Groundwater

The groundwater levels measured in the monitoring well installed during the current investigation are summarized in Table 6-7 below. It is noted that artesian conditions were encountered during drilling in previous BH6 which is located within the creek valley. Additional porewater pressure data is provided in Section 7.



These groundwater observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

Table 6-7: Summary of Groundwater Level Measurements

Borehole	Strata and Elevation within Screened Interval	Ground Surface Elevation (m)	Groundwater Level		
			Depth (mbgs)	Elevation (m)	Date of Measurement
MW 21-3	Varved Clay/Silt and Till (182.5 – 184.0)	216.1	3.5	212.6	January 15, 2021
			10.9	205.2	January 18, 2021
			12.1	204.0	January 29, 2021
			12.2	203.9	February 3, 2021

7. SLOPE MONITORING

Following completion of the borehole drilling, the installed instrumentation was monitored periodically on behalf of Thurber by Surveyors on Site (SOS) Inc. of New Liskeard, Ontario. The monitoring that was carried out included the following:

- Survey monitoring of the survey pins (change in easting, change in northing, change in elevation, and total displacement).
- Slope profiling (downslope and cross slope) of inclinometers 21-1 and 21-4.
- Porewater pressure (elevation head) measured in vibrating wire piezometers 21-2 and 21-5 and groundwater level readings in MW21-3.

In general, readings were collected on a weekly basis from January 18 to February 17, 2021 and monthly thereafter. The results of the monitoring are presented on the graphs provided in Appendix E.

The monitoring results demonstrated minimal slope movement except for a retrogressive failure of the headscarp that occurred at some point in time between July 8 and August 9, 2021. Upon learning of the retrogressive failure Thurber conducted an additional site reconnaissance on August 21, 2021. The following observations were made during the additional site reconnaissance:

- There have been at least two additional shallow slope failures (retrogressions) since Thurber's initial site reconnaissance in December 2020. The timing of the first retrogression is not clear; it is possible that it occurred weeks to months previously and went unnoticed by the survey staff since it did not impact the monitoring instrumentation.



- A second retrogression occurred more recently between July 8 and August 9, 2021 that affected some of the survey monitoring pins, some of which fell into the failure. This recent retrogression occurred at the southeast portion of the headscarp. The overall orientation of the headscarp has shifted slightly, so that the overall orientation of the failure is more southeast-northwest.
- The current headscarp is about 3 m high and near-vertical. It is not considered stable and further retrogression is likely.
- The creek water level at the culvert outlet appears to be approximately 2 m lower than the December 2020 site reconnaissance.
- The creek has been undercutting the toe of slope. Significant erosion has occurred since the December 2020 site reconnaissance. At the creek level, the slope “toe” is standing about 3 m high and is steeper than 1H:1V.

Additional photographs taken during the August 2021 site reconnaissance are provided in Appendix D.

The monitoring data collected since the August 2021 site reconnaissance does not indicate additional slope movement except for T1 which is now located within the failure. Overall, the total movement of the survey pins is less than approximately 50 mm since the start of monitoring except for T1 and T5, which have fallen into the failure since the latest retrogression.

The slope inclinometer casings have generally exhibited minimal movement, with a slight tilt of approximately 5 mm occurring above the ground surface. It is noted that an approximately 20 mm “bulge” in the casing of INC21-4 occurred between elevations 190 and 194 m. Thurber completed a site visit on April 7, 2021 to sound the inclinometer casing with a camera and at that time the pipe was intact and no abnormalities were observed. It should be noted that the graphs presented in Appendix E are exaggerated; the “bulge” observed in the down-hole camera was gradual and did not inhibit the movement on the slope inclinometer. The movement of the “bulge” has ceased as of the April 2021 monitoring session. The cause of the development of this “bulge” in the casing is not known; however, it appears likely that it was related to installation factors (e.g., grout settling) rather than movement of the slope.

The vibrating wire piezometers and monitoring well readings have been relatively stable since May 2021 with elevation head values in the range of 203 to 205 m. It is noted that the results indicate a downward hydraulic gradient. It is expected that the elevation head continues to increase higher in the deposit.



8. MISCELLANEOUS

The borehole and monitoring locations were selected in consultation with the Ministry of Transportation and were located in the field by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Surveyors on Site Inc. (SOS) following completion of the field program. Survey elevation benchmarks were provided by the MTO. Marathon Drilling Ltd. of Greely, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, monitoring installations and borehole decommissioning. The field investigation was supervised on a full-time basis by Jamil Pirani, E.I.T. and Chris Murray, P.Eng. of Thurber. Overall supervision of the investigation program was provided by Stephen Dunlop, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. The UCS, direct shear, and triaxial testing was completed by Stantec's laboratory in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Sarah Harrold, EIT, Stephen Dunlop, P.Eng. and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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**CALAMITY CREEK SLOPE FAILURE INVESTIGATION
HIGHWAY 11, 2.9 KM NORTH OF HWY 65 JUNCTION
NEW LISKEARD, ONTARIO
5018-E-0010, WORK ITEM NUMBER #7 AND #11**

G.W.P. NO. 5159-12-00

Geocres Number: 31M-133

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents geotechnical recommendations to assist the project team with the Calamity Creek Southwest Slope Failure located adjacent to Highway 11, approximately 2.9 km north of Highway 65 near New Liskeard, Ontario. The discussion and recommendations presented in this report are based on the information provided by the MTO and on the factual data obtained during the course of the investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

10. APPLICABLE CODES AND DESIGN CONSIDERATIONS

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed work, existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-19. The importance category and consequence classification are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation, Ontario (MTO).

Although, the new culvert installed beneath Highway 11 was designed to the “*Major Route*” importance category, the Geotechnical System represented by the slope has been evaluated based on the “Major Route” Importance Category.



It is understood, therefore, that the slope would have a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If this consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

As per Section 6.5.3.2 of the CHBDC, the degree of site prediction model understanding is considered to be *High* based on the current information which includes high complexity soil testing and instrumentation installation and monitoring.

As there are no structures on the slope, the fundamental period of vibration for the structure is assumed to be less than 0.5 s.

11. SEISMIC CONSIDERATIONS

11.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the Canadian Highway Bridge Design Code (CHBDC) is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). The seismic hazard for this site has been obtained from the GSC calculator. The data includes a peak ground acceleration (PGA), peak ground velocity (PGV) and the 5% spectral response acceleration values ($S_a(T)$) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including 475-year, 975-year and 2475-year events. The GSC seismic hazard calculated data sheet for this site is included in Appendix H.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA). At this site, the PGA for a reference Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.13g. This value is to be scaled by the $F(PGA)$ based on the site-specific Site Class.

11.2 Seismic Liquefaction

Per previous studies carried out at the site by Thurber and others, the potential for seismic liquefaction to be a factor at this site is low. As such, post-liquefaction slope stability analyses have not been carried out for this assessment.

11.3 Seismic Site Classification

This site has been classified as a Site Class E in accordance with Section 4.4.3.2 of the CHBDC (S6:19).

An $F(PGA)$ of 1.81 has been interpreted from Table 4.8 of the CHBDC S6:19 resulting in a design PGA of 0.23g for this site.



11.4 CHBDC Seismic Performance Category

As per Section 4.4.4 of the CHBDC, the Seismic Performance Category is assigned based on the fundamental period, the importance category and the spectral accelerations scaled to the site class. A Seismic Performance Category of 2 would be applicable for this site.

12. SLOPE STABILITY ASSESSMENT – EXISTING CONDITIONS

Slope stability analyses were carried out utilizing the commercially available slope stability program Slope/W (Version 11) of the GeoStudio software package developed by Geo-Slope International with the option for Morgenstern-Price method of slices for limit equilibrium analyses. Input parameters for the soils for the analysis are based on observations in the field and the results of in situ and laboratory testing. The slope geometry was based on topographic data provided by the MTO that was collected post-failure (in September 2021) using LiDAR technology. The topography and stratigraphy through the centre of the failure are presented on Drawing 3 in Appendix J. The stability analyses outputs are also provided in Appendix J. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis.

It is noted that the CHBDC does not provide target Factors of Safety for cut slopes. The following paragraphs utilize the target Factors of Safety from the CHBDC for embankment slopes as applicable to cut slopes. Table 6.2 of the CHBDC for embankment fills with a high degree of understanding and a Ψ of 1.0 generates minimum Factors of Safety of 1.43 and 1.25 for static permanent and static temporary conditions respectively for embankment slopes. However, based on MERO memorandum #2020-01 dated March 23, 2020, minimum Factors of Safety for static permanent and static temporary conditions can be reduced to 1.33 and 1.18, respectively, provided that this approach is approved by the MTO. Based on correspondence with the MTO for this project, the target factor of safety static conditions has been taken as 1.40.

For seismic analysis, several criteria must be satisfied:

- Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum resistance factor of 0.95 ($\Phi_{gu, static(temporary)} = 0.80 + 0.2$) for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.0, the minimum target Factor of Safety of 1.0 for this temporary condition with a high degree of understanding is appropriate for the pseudo-static seismic analysis incorporating loading from a 1 in 2475 year seismic event. Thus, slope stability measures should be carried out where the FS is less than 1.0 for the pseudo-static seismic analysis incorporating loading from a 1 in 2475 year seismic event.
- As per Section 6.14.9.1, where the pseudo-static Factor of Safety is greater than 1.3 for the pseudo-static seismic analysis incorporating loading from a 1 in 2475 seismic event., the slope is considered to be seismically stable with deformations of less than 50 mm.

- As is stated in Section 6.14.9.1, some embankment displacement can occur where the pseudo-static Factor of Safety is less than 1.3. Thus additional analysis is warranted where the FS is between 1.0 and 1.3 for the pseudo-static seismic analysis incorporating loading from a 1 in 2475 year seismic event. For this site, where there are no bridge foundation in the areas of the potential slip, the performance criteria of Section 6.14.2.3 of the CHBDC for a Major Route geotechnical system (embankment) outside a bridge interface zone, has been considered applicable. Therefore, major route sites that fall within Seismic Performance Category 2 or 3 shall have at least 50% of travelled lanes, but not less than one, available for use following ground motions with a return period of at least 475 years. Application of this overall philosophy for the present site produces the following secondary target: in cases where the FS for the pseudo-static seismic analysis incorporating loading from a 1 in 2475 year seismic event is between 1.0 and 1.3, an additional pseudo-static seismic analysis is carried out incorporating loading from a 1 in 475 year seismic event. A minimum target FS of 1.3 has been utilized for this secondary analysis.

For 1 in 2475 year seismic loading, the horizontal pseudo-static acceleration was taken as 50% of the peak ground acceleration (0.115g). For 1 in 475 year seismic loading, the horizontal pseudo-static acceleration was taken as 50% of the peak ground acceleration (0.081g).

The material properties used in the analyses are summarized in Table 12-1. These values are based on the in situ and laboratory testing results collected from the current investigation as well as published literature on New Liskeard varved clays and Thurber's experience. It is noted that anisotropic shear strength parameters (separate vertical and horizontal shear strength) were utilized to account for the varved nature of the clay deposit. It is also noted that the failed slope material will have lower strength properties; however, this has been neglected since the depth of the failed material is not known.

Table 12-1: Summary of Material Shear Strength Properties

Material	Unit Weight (kN/m ³)	Static Drained		Undrained Shear Strength (kPa)
		Friction Angle	Cohesion	
		(degrees)	(kPa)	
Organic Silt	12.5	26	0	-
Weathered Varved Clay	18	30 – vertical 26 – horizontal	0	80
Varved Clay 1 (EL. 210.9 to 212.4 m)	16.5	30 – vertical 26 – horizontal	0	75
Varved Clay 2 (below El. 210.9 m)	17.5	30 – vertical 26 – horizontal	0	40 – 75 (increasing linearly below El. 210.9 m)
Glacial Till	21	32	0	-
Bedrock	Impenetrable			



The porewater pressure conditions used in the slope stability model were based on the porewater pressure readings collected from the VWP's and monitoring well installed during the current investigation and were represented by a downward hydraulic gradient with flow relatively parallel to the slope face and exiting at the creek level assuming the static groundwater level is present at the base of the weathered crust.

The slope stability results of the existing slope are shown on the analysis sheets presented in Appendix J and are summarized as follows:

- Permanent, static-drained conditions (upper slope only) – FOS = $1.18 < 1.33 - 1.43$ (Figure J1)
- Permanent, static-drained conditions (lower slope only) – FOS = $1.06 < 1.33 - 1.43$ (Figure J2)
- Permanent, static-drained conditions (global slope) – FOS = $1.28 < 1.33 - 1.43$ (Figure J3)
- Temporary, static-undrained (global slope) – FOS = $1.16 < 1.18 - 1.25$ (Figure J4)
- Temporary, seismic-undrained for 2475-yr earthquake (global slope) – FOS = $0.81 < 1.0$ (Figure J5)

In addition, it is recognized that the existing porewater pressure (PWP) conditions may not represent the worst-case conditions (e.g., during the spring). Therefore, the analyses were also run with a 5% and 10% porewater pressure increase under static-drained conditions. The results of this analyses are summarized as follows:

- 5% PWP increase, static-drained conditions (upper slope only) – FOS = 1.14 (Figure J6)
- 5% PWP increase, static-drained conditions (global slope) – FOS = 1.25 (Figure J7)
- 10% PWP increase, static-drained conditions (upper slope only) – FOS = 1.13 (Figure J8)
- 10% PWP increase, static-drained conditions (global slope) – FOS = 1.22 (Figure J9)

All of the analyses presented above generated unacceptable factors of safety per guidance provided in the CHBDC. It is noted that the topographic model did not accurately model the upper

headscarp which is currently near vertical. Additional retrogression and failure of the upper headscarp is expected. Based on the natural slope that the bottom of the failure is tending towards (approximately 3.6H:1V), the headscarp should be expected to retrogress by another 10 to 20 m at a minimum.

13. REMEDIATION OPTIONS

The following slope remediation options were considered as part of this assessment:

- 1) Do nothing – the slope will continue to retrogress naturally until achieving a relatively stable geometry (i.e., a state of equilibrium). It is noted that the Calamity Creek valley is prone to slope failures with multiple recorded landslides in the past. Remediating the slope at this location will not prevent future landslides in other locations within the valley. It is also possible that any changes to the existing creek cross-section will initiate failures downstream. If this option is chosen it should be recognized that future failures/ retrogressions may encroach on the existing house located about 55 m south of the headscarp. Therefore, if this option is chosen it is recommended that the existing house located close to the headscarp be purchased by the MTO and demolished.
- 2) Flatten the slope – the factor of safety against global slope instability will improve if the overall slope inclination is flattened by removing soil from the crest of the slope. To assess this option, slope stability analyses were run with the slope cut back at inclinations of 3H:1V, 3.5H:1V, 4H:1V, and 4.5H:1V under static-drained conditions. The results of these analyses are shown on the analysis sheets presented in Appendix J and are summarized as follows:
 - 3H:1V – FOS = 1.14 (Figure J10). It is noted that this factor of safety is lower than the existing condition due to the loss of resisting force provided by the failed material near the base of the slope.
 - 3.5H:1V – FOS = 1.27 (Figure J11).
 - 4H:1V – FOS = 1.32 (Figure J12).
 - 4.5H:1V – FOS = 1.36 (Figure J13).

It is noted that achieving a target factor of safety of 1.40 is not possible unless an impractical slope (flatter than 4.5H:1V) is used, or if buttressing (Option 3 below) is used in conjunction with slope flattening. It is noted that the natural slope inclination that the slope failure is tending toward within the lower portion of the failure is approximately 3.6H:1V.

The approximate location of the new crest of slope for each of these scenarios is shown on Drawing 2 in Appendix AJ. At 4H:1V the slope significantly encroaches on the existing property and almost overlaps the water supply well. If this option is chosen, it would still be prudent to purchase the property and demolish the house. Otherwise, if the house remains occupied it is recommended that periodic monitoring of the slope be carried out in the future due to the potential for erosion of the toe precipitating future slope failures.

- 3) The creek can be infilled with OPSS.PROV 1010 Granular B Type II, or OPSS.PROV 1004 rip-rap (R-10 or R-50), or rock protection up to about elevation 194 m (i.e., the entire creek cross-section) to inhibit future erosion of the toe and act as a buttress, which will improve global slope instability. It is noted that this option will not improve the factor of safety of the upper slope that is still over-steepened and subject to future retrogressions unless this option is combined with Option 2 above; however, it will improve the factor of safety against global instability as well as reduce the potential for future under-cutting of the toe-of-slope from the creek that is presently eroding the valley slopes. The stability results of this option are shown on the analysis sheets presented in Appendix J and are summarized as follows:

- Buttress at the toe (global slope) – FOS = 1.32 (Figure J14).

It is noted that the factor of safety could be further increased if a thicker buttress is placed at the toe of the failure.

Other options including draining the slope and building a structural wall to retain the slope were also considered but are not considered feasible from a cost and constructability perspective and therefore are not discussed further herein.

A comparison of the technical advantages and disadvantages of each of the three options is presented in Appendix I.

14. RECOMMENDED APPROACH

It is recommended that Option 3, infilling the creek with a buttress consisting of Granular B Type II, rip-rap or rock protection, be implemented to inhibit future erosion of the toe, which could otherwise result in a large-scale global slope stability failure that could impact the existing house located close to the failure. It is noted that this option alone will not prevent future retrogressions at the upper portion of the slope; therefore, the upper slope should also be flattened to an inclination no steeper than 3.5H:1V (i.e., Option 3 should be combined with Option 2).

It is noted that this assessment is from a geotechnical slope stability perspective only and does not consider hydraulic and environmental impacts to the creek. It is understood that the MTO's preferred remediation includes a combination of Options 2 and 3 in conjunction with raising the creek level by means of placing a geosynthetic clay liner (GCL) over the new granular buttress.



Hydraulic and environmental experts should be also consulted to confirm the feasibility of this option and to comment on the design implications. It is noted that the buttress can consist of a hybrid combination of Granular B Type II, rip-rap and/or rock protection materials, if required for hydraulic/environmental reasons. However, differing materials with different gradations should be separated by a geotextile filter cloth to prevent migration of finer particles from one material into the void spaces of another materials. In addition, materials with larger particle sizes (e.g., rip-rap and rock projection) should only be placed over the Granular B Type II (not under the Granular B Type II).

The slope stability of the preferred option has been assessed based on a conceptual cross-section provided by the MTO, which includes a buttress constructed with Granular B Type II. The stability results of the conceptual design are shown on the analysis sheets presented in Appendix J and are summarized as follows:

- Buttress at the toe with 3.5H:1V upper slope flattening (lower slope only), static drained conditions – FOS = 1.44 (Figure J15).
- Buttress at the toe with 3.5H:1V upper slope flattening (global slope), static drained conditions – FOS = 1.40 (Figure J16).
- Buttress at the toe with 3.5H:1V upper slope flattening, seismic undrained conditions – FOS = 1.06 (Figure J17).

This recommended approach meets the target factor of safety of 1.4 for drained conditions that has been chosen for this project by the MTO.

The target factors of safety under seismic loading conditions have not been met with the recommended solution for either the 2475 or 475 year earthquakes. Additional remediation measures would be required to satisfy seismic loading conditions.

The treatment area should extend from the outlet of the existing culvert to approximately 10 m beyond the western edge of the failure for a total length of treatment of approximately 65 m.

It is noted that flattening of the upper slope will require destroying some of the slope monitoring instrumentation. However, in order to allow for slope monitoring post-construction, it is recommended that efforts be made to preserve and protect INC21-4 and VWP21-2 at a minimum, and as many other instruments as practical. Following construction, it is recommended that monthly monitoring of these instruments be carried out for at least 3 months, and then seasonally for at least 1-year post-construction. If maintaining these existing instruments is not possible, consideration can be given to reinstalling the instruments or alternatively carrying out periodic LiDAR scans of the slope to assess for post-construction movement.



It is noted that there is a history of slope stability failures within the Calamity Creek valley and there are inherent uncertainties with the slope stability analysis carried out by Thurber for this assignment, particularly as it related to future porewater pressure conditions. The recommended approach described above provides a theoretical factor of safety against global instability of 1.4 based on the assumptions described herein. If the MTO wishes to reduce risks further, consideration can be given to purchasing the property and demolishing the house regardless of which option is chosen. If the house is to remain occupied, periodic slope monitoring should be continued post-construction as described above. If post-construction slope movement continues to occur after the recommended approach is implemented, purchasing the house should be considered at that time.

15. CONSTRUCTION CONSIDERATIONS

It is noted that the slope in its current state is not considered stable and therefore working in the vicinity of the failure is inherently dangerous. To reduce the potential for instability as much as possible the following recommendations are provided:

- Construction should occur when the creek water level is low (i.e., during the summer).
- Stage 1 of the construction should commence by removing soil from the crest of slope to flatten the headscarp using a long-reach excavator. Heavy equipment should not be allowed near the edge of the headscarp. In this regard, the equipment should be no closer to the headscarp than INC21-1, as shown on Drawing 3. Overall, the upper slope should be flattened to an inclination of 3.5H:1V or flatter. It is noted that the lower portion of the slope that contains failed material should not be altered at this stage. This failed material on the lower portion of the slope is providing resisting force to prevent slope failure and should not be removed unless under the specific direction of a geotechnical engineer.
- Stage 2 can then commence by placing the Granular B Type II buttress material by end-dumping to fill the creek valley starting from the culvert outlet and progressing downstream until the Granular B Type II has completely infilled the creek up to elevation 194 m beyond the slope failure. Vibratory compaction of the Granular B Type II should not be permitted; it is noted that the Granular B Type II will be nominally compacted with the construction equipment, which is considered sufficient for the purpose of the proposed remediation. A haul road will need to be constructed to allow for access to the creek. A possible location of the haul road is shown on Drawing 1.
- During both stages of construction, stockpiling of excavated soil and imported fill should be avoided. Stockpiling could lead to potential issues with slope instability. Any soil that is excavated during Stage 1 should be removed from the site immediately, and any fill imported to the site as part of Stage 2 should be dumped and spread at its final location immediately.



- The contractor should prepare a submittal before construction commences that provides details on the proposed construction methodology, including equipment, setback distances, and sequencing. This submittal should be reviewed and approved by the Contract Administrator prior to the commencement of construction.

15.1 Excavations and Dewatering

Temporary excavations are not anticipated for this project; however, as a general guideline all permanent and temporary slopes should be inclined no steeper than 3.5H:1V for this project to avoid issues with slope instability. It is noted that this recommended slope is flatter than required by the Ontario Health and Safety Act (OHSA), but is considered required due to previous slope stability failures at the site, including multiple slope failures during the recent construction of the culvert.

Placement of the Granular B Type II within the creek valley can be carried out 'in-the-wet' from a geotechnical perspective. However, if this is not feasible from a hydraulics perspective it should be recognized that creek diversion will likely not be feasible. If creek flow needs to be diverted around the work zone during construction, it is anticipated that a sandbag cofferdam would be needed at the outlet of the culvert, and the water would need to be pumped and discharged downstream of the work zone.

15.2 Erosion Protection

The Contractor should provide silt fences and erosion control blankets as per OPSS 805 throughout the duration of construction to prevent transport of silt/sediment.

Scour and erosion protection should be provided along the banks of the reconstructed creek to prevent further erosion of the toe of slope. In addition, check dams may be required to reduce creek flow velocity to control erosion, particularly at the transition point where the new reconstructed creek (at a new higher elevation) meets the existing creek at a lower elevation. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field. It is noted that additional toe erosion and possibly future slope instability should be anticipated in untreated areas of the Calamity Creek Valley.

The ground surface within the failure scarp should also be protected from erosion either by means of a vegetative cover or granular sheeting. The primary advantage of a vegetative cover is that it can be placed by spray methods. This will allow for minimal work and disturbance within the failure, which is particularly beneficial within the lower portion of the slope where the failed material is acting as a resisting force to slope instability. The disadvantage of a vegetative cover is that it may inhibit subsurface drainage. In contrast, granular sheeting will allow for free drainage of the slope; however, it will require reworking the hummocky nature of the failed material, and the ground surface within the failure may not be stable for earth-moving equipment. Overall, the risk of inhibiting subsurface drainage with a vegetative cover is considered low; therefore, this method is preferred over a layer of granular sheeting.



16. CLOSURE

Stephen Dunlop, P.Eng. and Dr. Fred Griffiths, P.Eng. prepared this Foundation Investigation and Design Report. Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



Appendix A.
Monitoring Plan

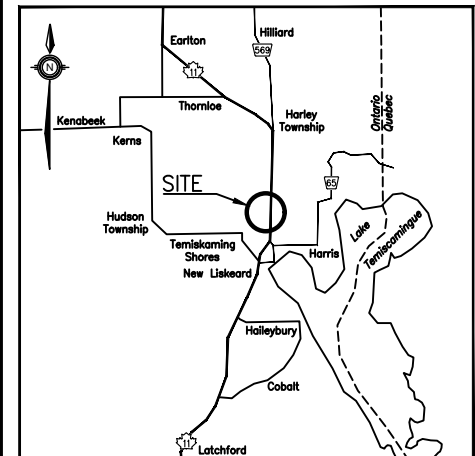
MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 11
CALAMITY CREEK
SLOPE FAILURE
MONITORING PLAN

SHEET



KEYPLAN

LEGEND

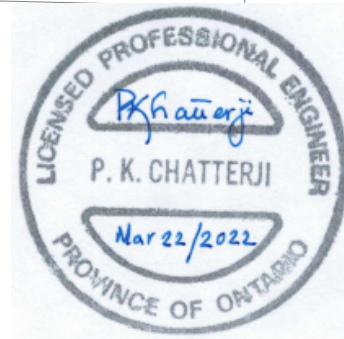
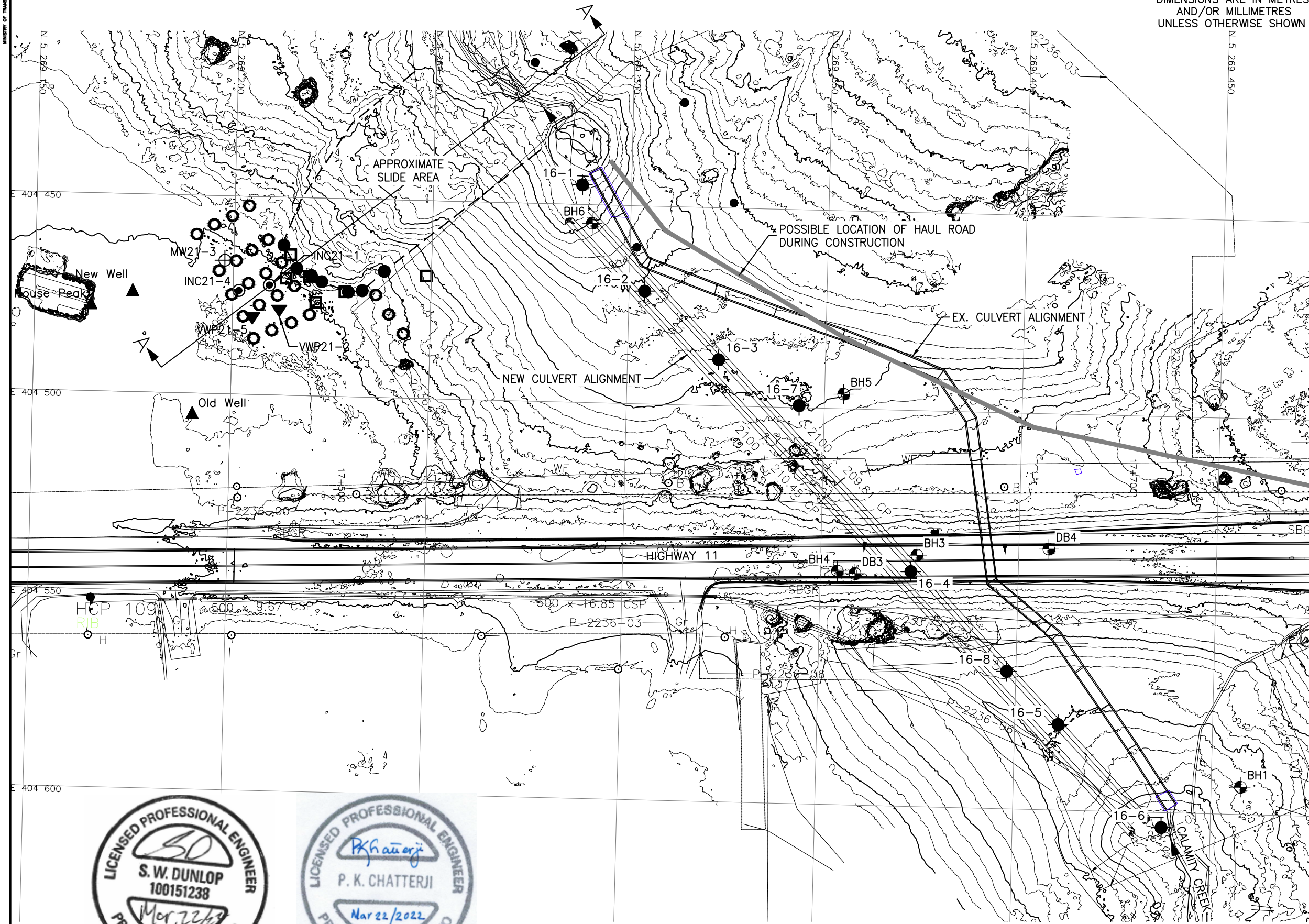
- Borehole by Thurber
- Borehole by Others
- Monitoring Well
- Inclinometer
- Vibrating Wire Piezometer
- Approx. Crest of Failure
- Approx. Location of Survey Monitoring Post
- Approx. Location of Survey Monitoring Pipe
- Other

NO	ELEVATION	NORTHING	EASTING
INC21-1	216.2	5 269 209.1	404 472.3
INC21-4	216.2	5 269 201.5	404 473.9
MW21-3	216.1	5 269 197.8	404 466.3
VWP21-2	216.4	5 269 211.8	404 478.8
VWP21-5	216.2	5 269 205.0	404 480.8
16-1	194.3	5 269 287.6	404 445.1
16-2	200.5	5 269 303.9	404 471.5
16-3	203.2	5 269 323.0	404 488.4
16-4	213.4	5 269 372.9	404 540.7
16-5	204.0	5 269 411.0	404 578.4
16-6	198.1	5 269 437.6	404 603.8
16-7	204.2	5 269 343.6	404 499.5
16-8	206.9	5 269 397.6	404 565.3

-NOTES-

- Coordinate system is MTM NAD 83 Zone 12.
- Slope failure coordinates:
5 269 240 N; 404 450 E

GEOCRES No. 31M-133



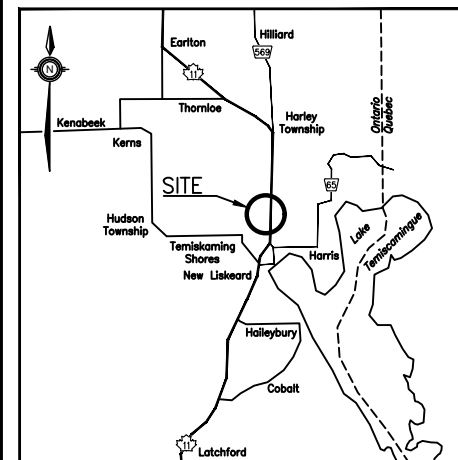
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SD	CHK -	CODE
DRAWN	MFA	CHK SD	SITE
			LOAD
			STRUCT
			DWG 1
			DATE MAR 2022

FILENAME: H:\Drafting\30000\30624\TED-30624-MOPL.dwg
PLOTDATE: 5/16/2022 9:29 AM

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 11
CALAMITY CREEK
SLOPE FAILURE
MONITORING PLAN



KEYPLAN

LEGEND

- | | |
|--|--|
| | Borehole by Thurber |
| | Borehole by Others |
| | Monitoring Well |
| | Inclinometer |
| | Vibrating Wire Piezometer |
| | Approx. Crest of Failure |
| | Approx. Location of Survey Monitoring Post |
| | Approx. Location of Survey Monitoring Pipe |
| | Other |

[illegible]

-NOTES-

1) Coordinate system is MTM NAD 83 Zone 12.

GEOCRES No. 31M-133

[illegible]



Appendix B.

Record of Borehole Sheets from the Current Investigation



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT “N” Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No INC21-1

1 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 209.1 E 404 472.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.13 - 2021.01.13 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W P	W	W L		
216.2								20 40 60 80 100							
0.0	CLAYEY ORGANIC SILT (OH) dark brown very loose to loose						216								
215.6															
0.6	Varved CLAY (CH) grey-brown very stiff to stiff fissured						215								
							214								
							213								
212.4															
3.8	Varved CLAY (CH) grey stiff						212								
							211								
210.9															
5.3	Varved CLAY and SILT (CL/CI) grey firm						210								
							209								
							208								
							207								

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+³, ×³: Numbers refer to Sensitivity
 20
 15
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 (%) STRAIN AT FAILURE


ONTMT4S 30624 CALAMITY CREEK.GPJ 2012TEMPLATE(MTO).GDT 21-12-10

RECORD OF BOREHOLE No INC21-1

2 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 209.1 E 404 472.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.13 - 2021.01.13 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE				W P W W L								
								● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page							20	40	60	80	100	20	40	60					
	Varved CLAY and SILT (CL/CI) grey firm						206		4.9 +											
										6.5 +										
										4.4 +										
								205		5.7 +										
										7.8 +										
										8.5 +										
								204												
										4.3 +										
										5.3 +										
										5.0 +										
								203												
										3.8 +										
										3.9 +										
								202		4.8 +										
										4.0 +										
										3.7 +										
								201												
							4.0 +													
							7.0 +													
							4.0 +													
					200															
							3.7 +													
							3.1 +													
					199		4.8 +													
							4.5 +													
							3.3 +													
					198															
							4.1 +													
							4.7 +													
197.3							197		3.5 +											
18.9	Varved CLAY (CH) and SILT (MH) grey firm								3.1 +											

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+³, ×³: Numbers refer to Sensitivity
 20
 15 10 5 0
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No INC21-1

3 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 209.1 E 404 472.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.13 - 2021.01.13 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W _P	W	W _L		
								20 40 60 80 100				20 40 60			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)			
	Continued From Previous Page							20 40 60 80 100							
	Varved CLAY (CH) and SILT (MH) grey firm						196			3.1 +					
									5.3 +						
									4.6 +						
									4.0 +						
							195								
									3.3 +						
									5.6 +						
							194								
									3.9 +						
									3.8 +						
							193								
									3.0 +						
									5.8 +						
									5.3 +						
									3.9 +						
192															
		3.4 +													
		4.1 +													
191															
		3.9 +													
		4.0 +													
190															
		3.2 +													
		6.0 +													
		4.2 +													
189															
		3.7 +													
		2.9 +													
		5.3 +													
188															
		4.3 +													
		3.8 +													
187															
		3.7 +													
		3.9 +													
		4.2 +													

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+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20 40 60 80 100									20 40 60		
	Continued From Previous Page																		
185.4	Varved CLAY (CH) and SILT (MH) grey firm						186												
30.8	SILTY CLAY (CL-ML) some sand, gravel, and cobbles grey stiff GLACIAL TILL		1	GS	-		185												
184.4																			
31.8	SANDSTONE BEDROCK occasional vugs thinly to medium bedded fine to coarse grained fresh grey strong to very strong		1	RUN			184												
			2	RUN			183												
182.0																			
34.2	End of Borehole Slope Inclinator Installed Core Measurements: Run: TCR: SCR: RQD: 1 100% 100% 100% 2 100% 97% 31%						182												


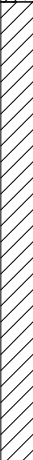


+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No INC21-4

1 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 201.5 E 404 473.9 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.16 - 2021.01.16 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
216.2							20	40	60	80	100	W _P	W	W _L				
0.0	CLAYEY ORGANIC SILT (OH) dark brown very loose to loose		1	GS	4													
215.6																		
0.6			Varved CLAY (CH) grey-brown very stiff to stiff fissured		2	SS	8											
					3	SS	5											
			4	SS	3													
			5	SS	1													
212.4	Varved CLAY (CH) grey stiff		6	SS	WH													
			7	SS	WH													
210.9	Varved CLAY and SILT (CL/Cl) grey firm		8	SS	WH													
5.3																		
			9	SS	WH													
					10	SS	WH											
			11	SS	WH													

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+³, ×³: Numbers refer to Sensitivity
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 (%) STRAIN AT FAILURE


ONTMT4S 30624 CALAMITY CREEK.GPJ 2012TEMPLATE(MTO).GDT 21-12-10

RECORD OF BOREHOLE No INC21-4

2 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 201.5 E 404 473.9 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.16 - 2021.01.16 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE												
	Continued From Previous Page																						
	Varved CLAY and SILT (CL/CI) grey firm						206																
			12	SS	WH																		
			13	SS	WH																		
			14	SS	WH																		
			15	SS	WH																		
			16	SS	WH		199																
			17	SS	WH		198																
197.3																							
18.9	Varved CLAY (CH) and SILT (MH) grey firm						197																

ONTMT4S 30624 CALAMITY CREEK.GPJ 2012TEMPLATE(MTO).GDT 21-12-10

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+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No INC21-4

3 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 201.5 E 404 473.9 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.16 - 2021.01.16 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page							20 40 60 80 100				W P W W L		GR SA SI CL		
	Varved CLAY (CH) and SILT (MH) grey firm		18	SS	WH		196									
			19	SS	WH											
			20	SS	1				193							
			21	SS	1											
			22	SS	3											
			23	SS	1		187									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15 10 5 0
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No INC21-4

4 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 201.5 E 404 473.9 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Slope inclinometer installed with CME 55 Trackmount (HW Casing, HQ coring) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.16 - 2021.01.16 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W P W W L WATER CONTENT (%)					
	Continued From Previous Page						20	40	60	80	100	20	40	60					
185.4	Varved CLAY (CH) and SILT (MH) grey firm		24	SS	4		186												
30.8	SILTY CLAY (CL-ML) some sand, gravel, and cobbles grey stiff GLACIAL TILL						185									3	5	69	23
184.5																			
31.7	SANDSTONE BEDROCK occasional vugs thinly to medium bedded fine to coarse grained fresh grey strong to very strong		1	RUN			184												
				2	RUN			183											
182.0																			
34.2	End of Borehole Slope Inclinometer Installed Core Measurements: Run: TCR: SCR: RQD: 1 100% 100% 88% 2 100% 98% 83%																		

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MW21-3

1 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 197.8 E 404 466.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Monitoring well installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.15 - 2021.01.14 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60			
216.1														
0.0	CLAYEY ORGANIC SILT (OH) dark brown very loose to loose						216							
215.5														
0.6	Varved CLAY (CH) grey-brown very stiff to stiff fissured						215							
							214							
							213							
212.3														
3.8	Varved CLAY (CH) grey stiff						212							
							211							
210.8														
5.3	Varved CLAY and SILT (CL/CI) grey firm						210							
							209							
							208							
							207							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MW21-3

2 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 197.8 E 404 466.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Monitoring well installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.15 - 2021.01.14 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80					
	Continued From Previous Page															
	Varved CLAY and SILT (CL/CI) grey firm						206									
							205									
							204									
							203									
							202									
							201									
							200									
							199									
							198									
197.2																
18.9	Varved CLAY (CH) and SILT (MH) grey firm						197									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

Continued Next Page

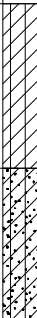
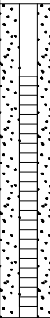
+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No MW21-3

4 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 197.8 E 404 466.3 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Monitoring well installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.15 - 2021.01.14 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT				
Continued From Previous Page															
185.0	Varved CLAY (CH) and SILT (MH) grey firm		2	SS	7		186								
31.1	SILTY CLAY (CL-ML) some sand, gravel, and cobbles grey stiff GLACIAL TILL						185								
184.0			3	SS	REF										
32.1	End of Borehole - Refusal on Probable Bedrock Stickup 50 mm diameter PVC monitoring well installed. Well Readings: Date: Depth (m): Elevation (m): 01/15/2021 3.5 212.6 01/18/2021 10.9 205.2 01/29/2021 12.1 204.0 02/03/2021 12.2 203.9 02/10/2021 12.4 203.7 02/17/2021 12.4 203.7 02/24/2021 12.5 203.6 03/24/2021 12.7 203.4 04/07/2021 12.7 203.4 05/05/2021 12.8 203.3 06/02/2021 12.9 203.2 07/08/2021 12.9 203.2 08/08/2021 12.9 203.2 09/09/2021 12.9 203.2 10/07/2021 12.9 203.2 11/07/2021 12.8 203.3 12/06/2021 12.8 203.3														

+³ ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No VWP21-2

1 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 211.8 E 404 478.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.11 - 2021.01.12 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
				WATER CONTENT (%)									
216.4							20 40 60 80 100						
0.0	CLAYEY ORGANIC SILT (OH) dark brown loose		1	SS	6								
215.8													
0.6	Varved CLAY (CH) grey-brown very stiff to stiff fissured		2	SS	6								
			3	SS	5								
			4	SS	4								
			1	TW	-								
212.6													
3.8	Varved CLAY (CH) grey stiff		2	TW	-								
			3	TW	-								
211.1													
5.3	Varved CLAY and SILT (CL/CI) grey firm		4	TW	-								
			5	TW	-								
			6	TW	-								
			7	TW	-								
			8	TW	-								
			9	TW	-								

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

ONTMT4S 30624 CALAMITY CREEK.GPJ 2012TEMPLATE(MTO).GDT 21-12-10

RECORD OF BOREHOLE No VWP21-2

2 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 211.8 E 404 478.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.11 - 2021.01.12 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE							
										20 40 60 80 100	20 40 60					
	Continued From Previous Page															
197.5 <																

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No VWP21-2

3 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 211.8 E 404 478.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.11 - 2021.01.12 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W P W W L				GR SA SI CL					
								20 40 60 80 100														
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)									
	Continued From Previous Page		16	TW	-		196								○							
	Varved CLAY (CH) and SILT (MH) grey firm																					
		17	TW	-		195									○							
						194																
		18	TW	-		193									○							
						192																
		19	TW	-		191										○						
		20	TW	-		190										○						
								189								○						
								188														
				22	TW	-		187								○						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No VWP21-2

4 OF 4

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 211.8 E 404 478.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.11 - 2021.01.12 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20 40 60						
			</											

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No VWP21-5

1 OF 3

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 205.0 E 404 480.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.15 - 2021.01.15 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
216.2								20 40 60 80 100							
0.0	CLAYEY ORGANIC SILT (OH) dark brown very loose to loose						216								
215.6															
0.6	Varved CLAY (CH) grey-brown very stiff to stiff fissured						215								
							214								
							213								
212.4															
3.8	Varved CLAY (CH) grey stiff						212								
							211								
210.9															
5.3	Varved CLAY and SILT (CL/CI) grey firm						210								
							209								
							208								
							207								

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15 10 5 0
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No VWP21-5

2 OF 3

METRIC

GWP# 5159-12-00 LOCATION Calamity Creek, MTM Zone 12 N 5 269 205.0 E 404 480.8 ORIGINATED BY JP
 HWY 11 BOREHOLE TYPE Vibrating wire piezometer installed with CME 55 Trackmount (HW Casing) COMPILED BY SH
 DATUM Geodetic DATE 2021.01.15 - 2021.01.15 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)						
								20	40	60	80	100	W _p			W	W _L
								○ UNCONFINED			+	FIELD VANE					
						● QUICK TRIAXIAL			×	LAB VANE							
	Continued From Previous Page																
	Varved CLAY and SILT (CL/CI) grey firm						206										
							205										
							204										
							203										
							202										
							201										
							200										
							199										
							198										
197.3																	
18.9	Varved CLAY (CH) and SILT (MH) grey firm						197										

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
(%) STRAIN AT FAILURE

METRIC

+³, ×³: Numbers refer to Sensitivity



Appendix C.

Laboratory Testing from the Current Investigation

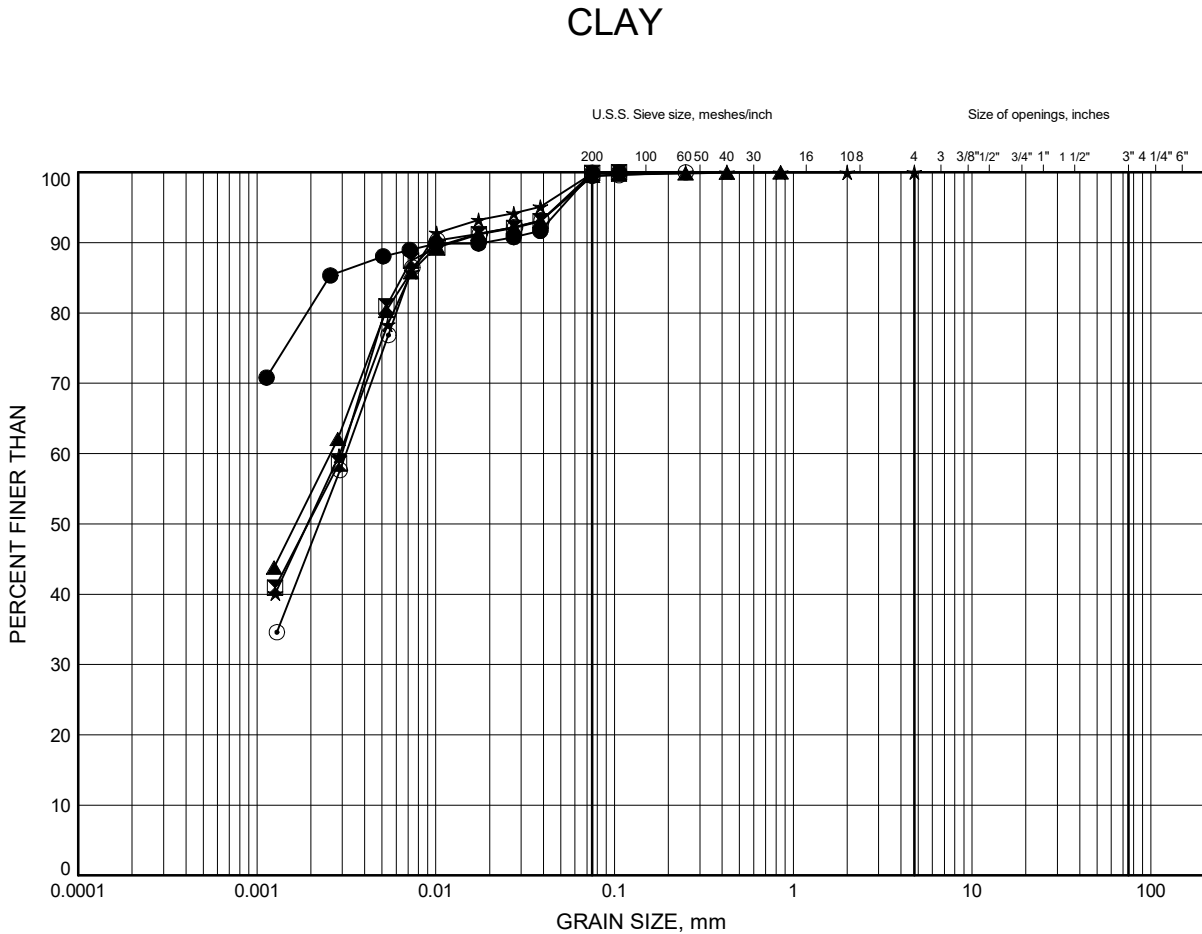


Appendix C.1

Particle Size Analysis and Atterberg Limits Figures

Calamity Creek Slope Failure Investigation GRAIN SIZE DISTRIBUTION

FIGURE C1



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	INC21-4	4.1	212.1
⊠	INC21-4	7.9	208.3
▲	INC21-4	12.5	203.7
★	INC21-4	18.6	197.6
⊙	INC21-4	24.7	191.5

Date March 2022

GWP# 5159-12-007

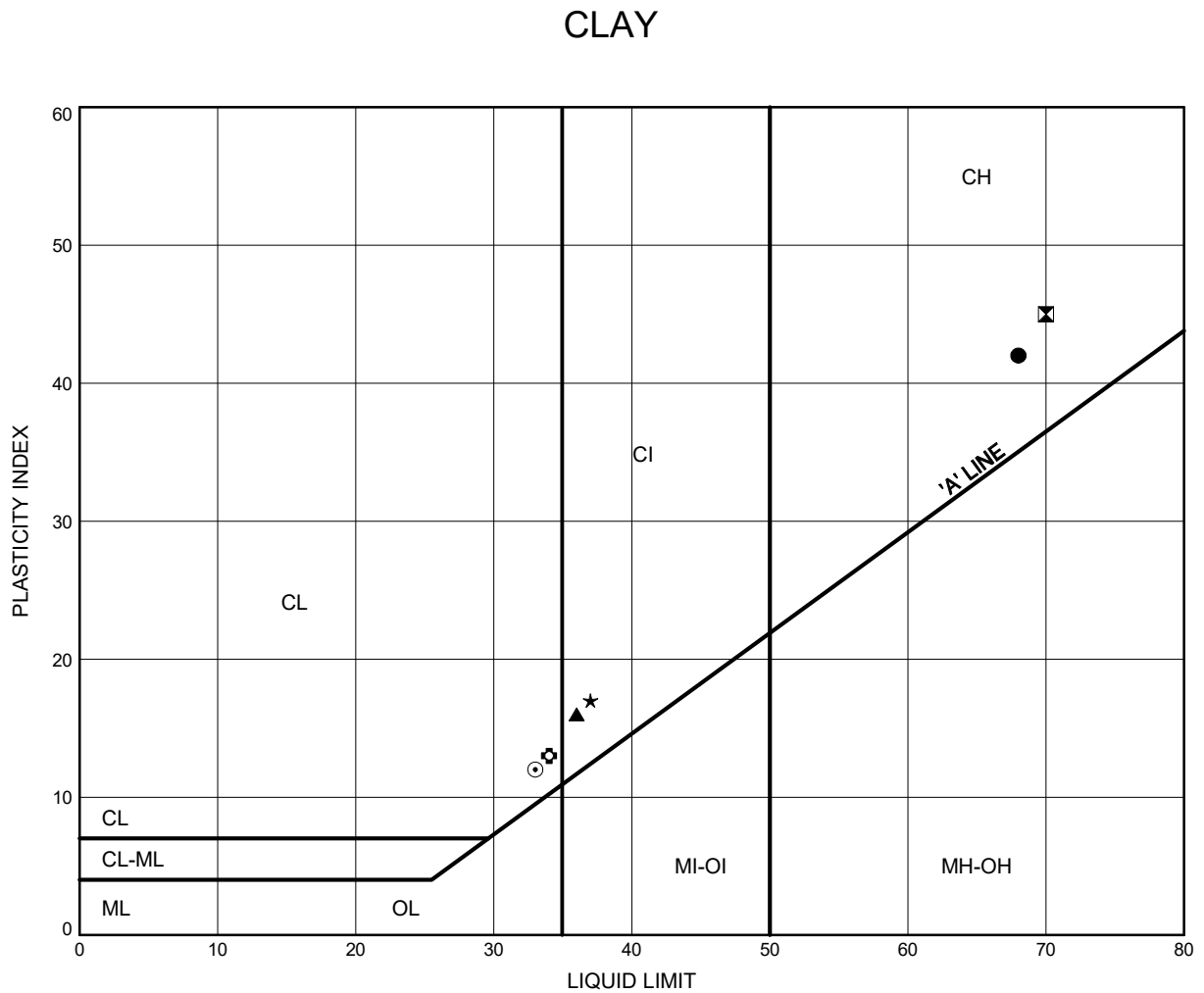


Prep'd SH

Chkd. SD

Calamity Creek Slope Failure Investigation
ATTERBERG LIMITS TEST RESULTS

FIGURE C2



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	INC21-4	1.8	214.4
⊠	INC21-4	4.1	212.1
▲	INC21-4	7.9	208.3
★	INC21-4	12.5	203.7
⊙	INC21-4	18.6	197.6
⊕	INC21-4	24.7	191.5

Date March 2022
 GWP# 5159-12-007

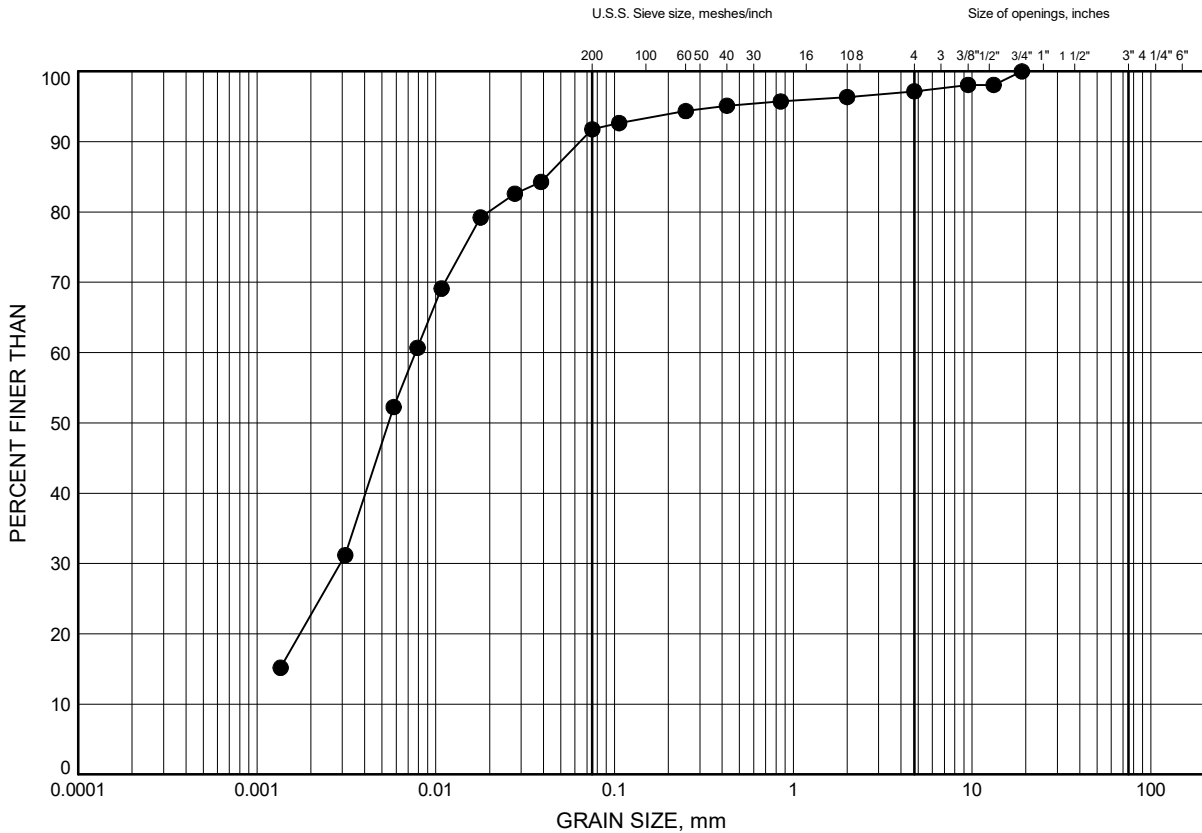


Prep'd SH
 Chkd. SD

Calamity Creek Slope Failure Investigation GRAIN SIZE DISTRIBUTION

FIGURE C3

GLACIAL TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	INC21-4	30.9	185.3

Date March 2022
GWP# 5159-12-007



Prep'd SH
Chkd. SD



Appendix C.2

Stantec UCS, Direct Shear, and Triaxial Test Results



Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

March 9, 2021
File: 122410864

Attention: Stephen Dunlop, M.A.Sc., P.Eng.
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
e-mail: sdunlop@thurber.ca

Dear Mr. Dunlop,

Reference: Unconfined Compression, Consolidated Undrained and Direct Simple Shear Tests Results, Thurber Consulting Ltd., File #30624: BH21-2, TW 3, 4, 5, 6, 7, 8, 9, 10, 11 & 12: sampled on January 11, 2021

This letter presents the results of seven unconfined compression tests, six consolidated undrained triaxial compression tests, and three direct simple shear tests under consolidated drained conditions carried out on the referenced samples, as provided in Table below in accordance with ASTM D2166, ASTM D4767 and ASTM 3080/D3080M/AASHTO T238, respectively. The test results are provided in the attached figures.

Table: Summary of Tests Completed on Selected Samples

Test Name	Sample Number
Unconfined Compression Test	BH21-2 TW3, 6, 7, 8, 11 & 12
Consolidated Undrained Triaxial Compression Test	BH21-2 TW4 & TW9
Direct Simple Shear Test (Consolidated Drained Conditions)	BH21-2 TW5 & TW10

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

STANTEC CONSULTING LTD.

Rajib Dey Ph.D., P.Eng.
Geotechnical Engineer
Phone: 905 944 6190
Fax: 905 474 9889
Rajib.Dey@stantec.com

Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

March 9, 2021
March 9, 2021

Date:
Date:

D. Boateng
R. Dey

Checked by:
Approved by:

Sample Details	Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW4	TW4	TW4
Depth	17½-19½ ft	17½-19½ ft	17½-19½ ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	1	2	3
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Soil Description & Classification

Silty clay, brown/grey, varved, moist			
Specific Gravity of Solids	2.740	2.740	2.740
Additional Notes (unusual conditions or other information necessary to interpret the test results):			
One specific gravity test performed for all three specimens			
Specimen 2 & 3 were consolidated in stages until the stipulated effective consolidation stresses			
Consolidation stresses provided by client			
Departures from the test procedure outlined in ASTM D4767-11 (2020):			

Initial Specimen Conditions

Height	mm	140.0	140.0	140.0
Diameter	mm	70.0	70.0	70.0
Dry Unit Weight	Mg/m ³	1.08	1.09	1.12
Void Ratio		1.53	1.50	1.43
Water Content	%	54.53	52.35	49.81
Degree of Saturation	%	97.9	95.5	95.2
Method used for obtaining water content		Cuttings	Cuttings	Cuttings

Membrane Properties

Young's Modulus	kPa	1400	1400	1400
Thickness	mm	0.3	0.3	0.3

Filter-Paper Strip Properties

Load carried per unit length	kN/mm	0.00019	0.00019	0.00019
Specimen perimeter covered by strips	mm	220	220	220

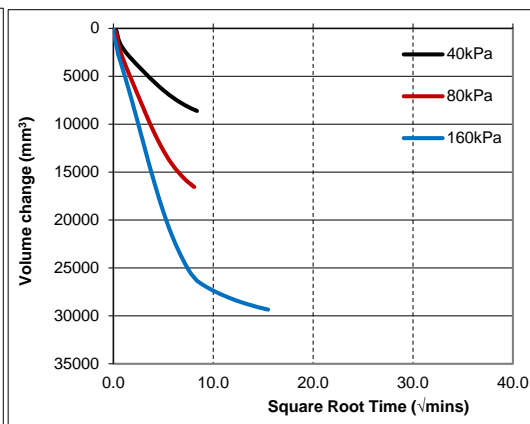
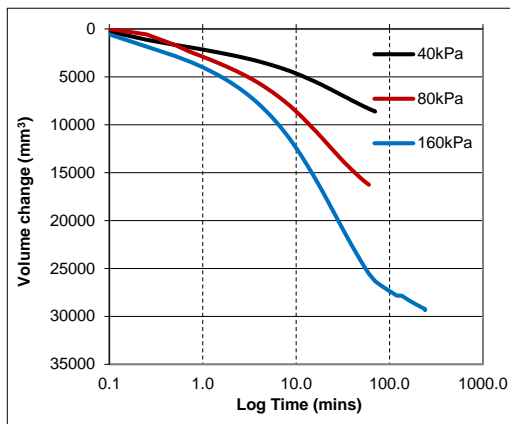
Consolidated Undrained Triaxial Compression Test for Cohesive Soils ASTM D4767 - 11 (2020)

Sample Details	Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW4	TW4	TW4
Depth	17½-19½ ft	17½-19½ ft	17½-19½ ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	1	2	3
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Test Setup	Specimen 1	Specimen 2	Specimen 3
Date Started	February 12, 2021	February 13, 2021	February 14, 2021
Date Finished	February 13, 2021	February 14, 2021	February 16, 2021
Top Drain Used	Yes	Yes	Yes
Base Drain Used	Yes	Yes	Yes
Side Drains Used (Filter-Paper Strips)	Yes	Yes	Yes
Pressure System Number	21706	21706	21706
Cell Number	21969	21969	21969

Measurement of Pore Pressure Parameter	Specimen 1	Specimen 2	Specimen 3
Cell Pressure Increment kPa	10.0	10.0	10.0
Cell Pressure at B determination kPa	100.0	100.0	100.0
Back Pressure at B determination kPa	90.0	90.0	90.0
Pore Pressure at B determination (initial) kPa	76.3	76.4	76.3
Pore Pressure at B determination (final) kPa	86.3	86.3	86.3
Pore Pressure Parameter B at 2 min	1.0	1.0	1.0
Method used for specimen saturation	Wet	Wet	Wet

End of Consolidation Stage	Specimen 1	Specimen 2	Specimen 3
Consolidation Stress kPa	40.0	80.0	160.0
Effective Consolidation Stress kPa	41.4	81.2	160.1
Total Back Pressure kPa	100.0	100.0	100.0
Time to 50 % primary consolidation min	11	12	31
Interpretation method used for t50	1	1	1
Dry Unit Weight Mg/m ³	1.14	1.12	1.17
Void Ratio	1.45	1.42	1.29
Water Content %	52.94	51.99	46.99
Degree of Saturation %	100.0	100.0	100.0
Cross-sectional Area, A _c mm ²	4033.8	3760.8	3676.4
Method used to determine Area, A _c	Method A	Method A	Method A

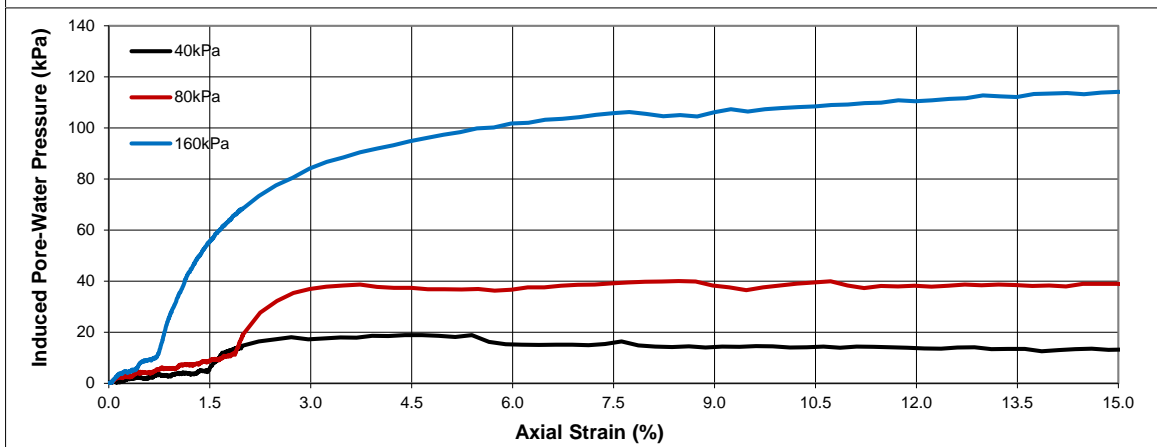
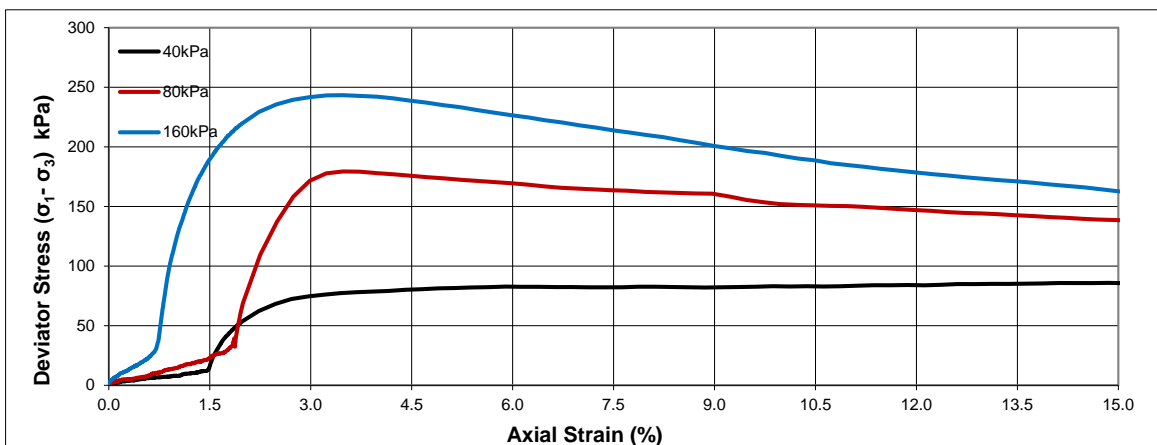


Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

Sample Details	Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW4	TW4	TW4
Depth	17½-19½ ft	17½-19½ ft	17½-19½ ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	1	2	3
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Shearing Stage			
Failure Criterion	15% Axial Strain	15% Axial Strain	15% Axial Strain
Rate of axial strain %/min	0.0166	0.0166	0.0166

Response at Failure				
Maximum Deviator Stress ($\sigma_1 - \sigma_3$)	kPa	85.9	179.4	243.4
Axial Strain at ($\sigma_1 - \sigma_3$) maximum	%	14.8	3.5	3.5
Max Effective Principal Stress Ratio (σ'_1 / σ'_3)		4.9	5.3	4.9
Deviator Stress at (σ'_1 / σ'_3) maximum	kPa	82.1	179.4	226.6
Axial Strain at (σ'_1 / σ'_3) maximum	%	5.4	3.5	6.0
Effective Major Principal Stress (σ'_1)	kPa	112.8	221.1	314.9
Effective Minor Principal Stress (σ'_3)	kPa	26.9	41.7	71.6
Values corrected for membrane?		Yes	Yes	Yes
Values corrected for filter-paper strips?		Yes	Yes	Yes



Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

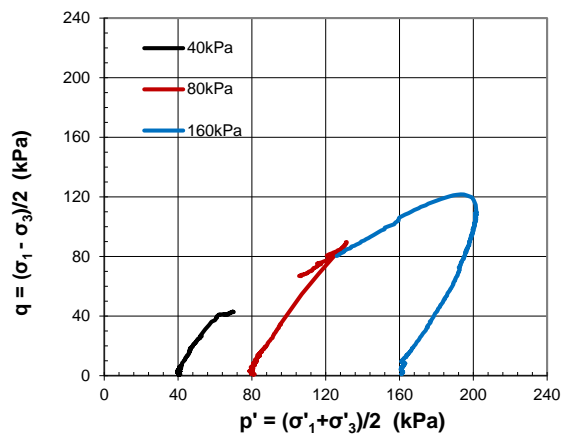
Specimen 1

Specimen 2

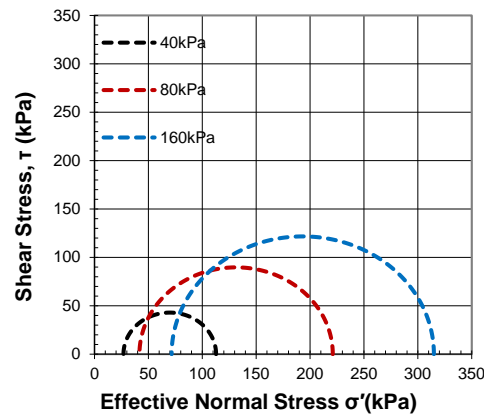
Specimen 3

Sample Details

Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW4	TW4	TW4
Depth	17½-19½ ft	17½-19½ ft	17½-19½ ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	1	2	3
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng



Mohr's Circles



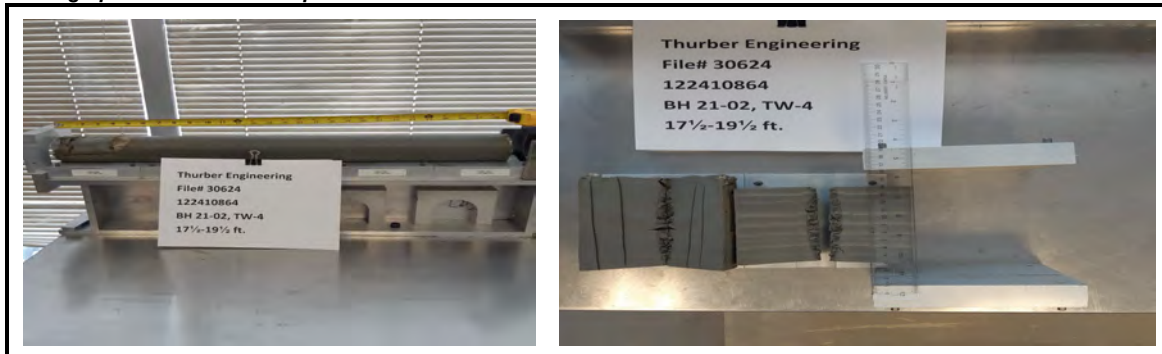
Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

March 9, 2021
March 9, 2021

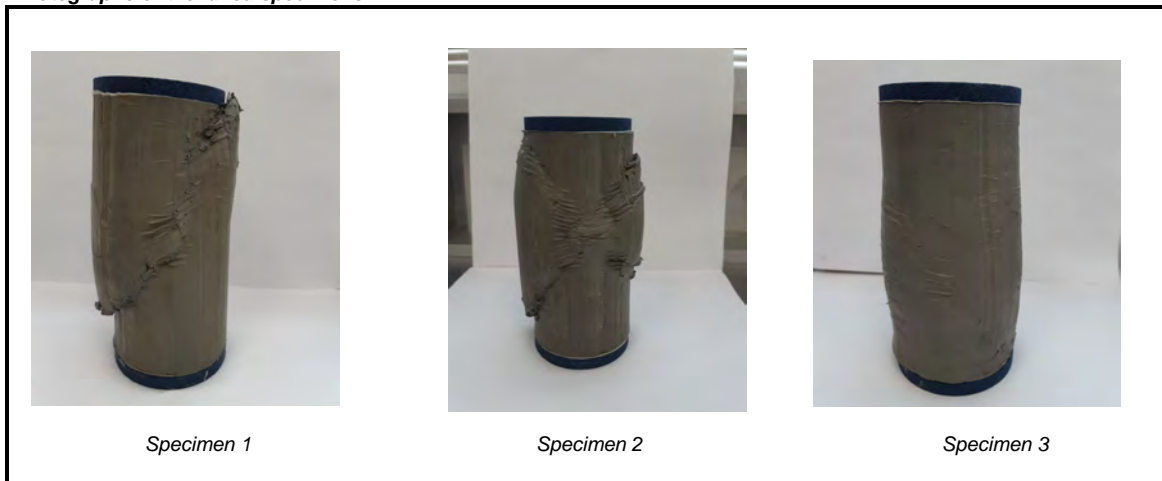
Checked by: D. Boateng
Approved by: R. Dey

Sample Details	Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW4	TW4	TW4
Depth	17½-19½ ft	17½-19½ ft	17½-19½ ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	1	2	3
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Photographs of the extruded specimen and sliced sections



Photographs of the failed specimens



Direct Shear Test of Soils Under Consolidated Drained Conditions ASTM D3080/D3080M

March 9, 2021
March 9, 2021

Date:
Date:

D. Boateng
Rajib Dey

Prepared by:
Checked by:

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March 9, 2021

Filename:
Date:

Specimen Details	Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample No.	TW5	TW5	TW5
Depth	20-22	20-22	20-22
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021

Soil Description & Classification

Silty clay, brown/grey, varved, moist

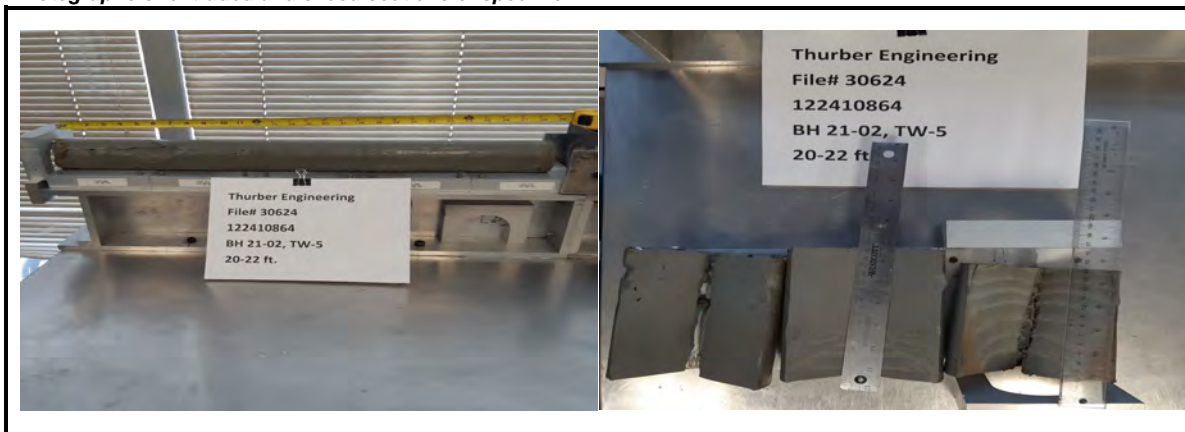
Initial Specimen Conditions

Height	mm	31.70	31.70	31.70
Diameter	mm	63.50	63.50	63.50
Mass	g	170.30	172.80	173.60
Dry Mass	g	112.38	115.39	114.33
Wet Density	Mg/m ³	1.70	1.72	1.73
Dry Density	Mg/m ³	1.12	1.15	1.14
Moisture Content	%	51.55	49.76	51.84
Degree of Saturation	%	97.3	99.0	100.0
Specific Gravity		2.740	2.740	2.740
Void Ratio		1.45	1.38	1.42

Final Specimen Conditions

Normal Stress	kPa	40	80	160
Time to Failure	min	399	404	422
Rate of Displacement	mm/min	0.024	0.024	0.024
Peak Shear Stress	kPa	20.6	41.2	81.9
H. Displacement-Peak	mm	10.1	10.2	9.7
Moisture Content	%	53.20	47.74	42.94

Photographs of extruded and sliced sections of specimen



Tests Notes:

1. Specimens inundated during the entire test
2. Tests specimen two & three were consolidated in stages of 24hrs to a maximum of 80 & 160 kPa respectively
3. Specific gravity of solids assumed for all three specimens
4. Consolidation stresses provided by client



Direct Shear Test of Soils Under Consolidated Drained Conditions
ASTM D3080/D3080M

March 9, 2021
March 9, 2021

Date:
Date:

D. Boateng
Rajib Dey

Prepared by:
Checked by:

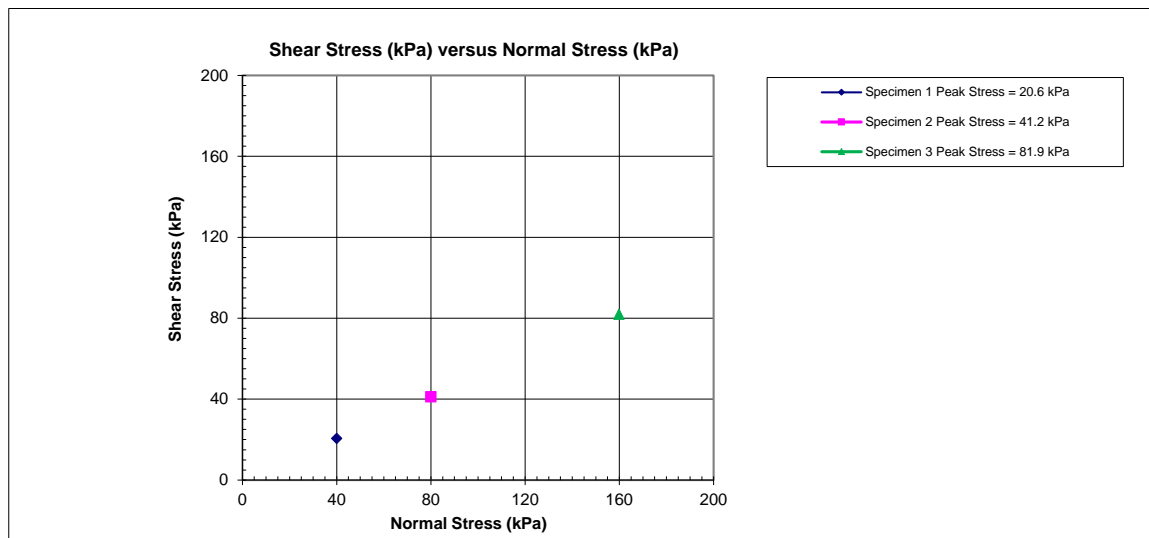
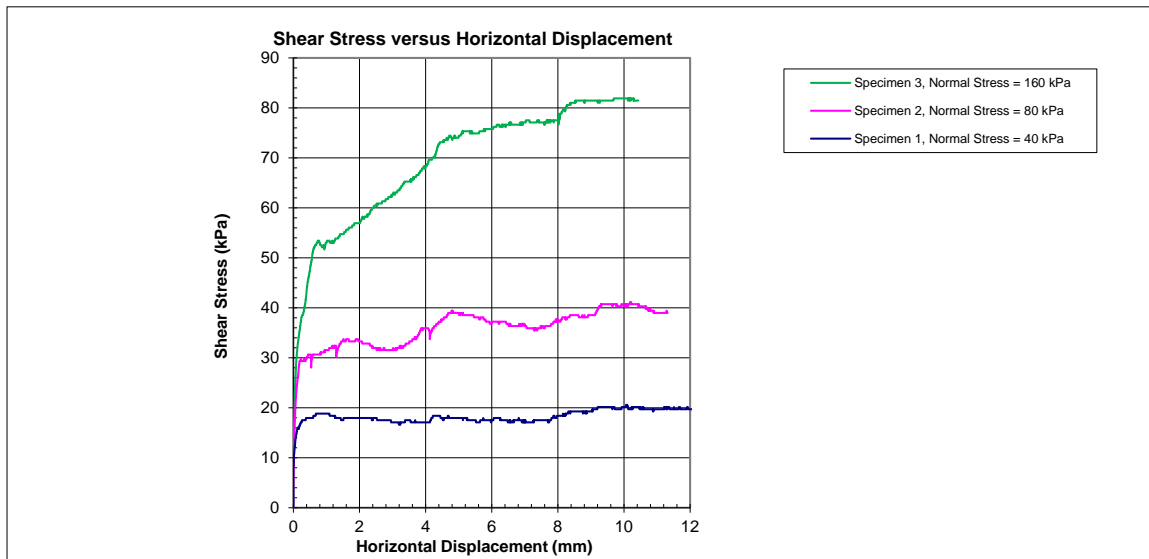
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March 9, 2021

Filename:
Date:

Specimen 1		Specimen 2		Specimen 3	
Specimen Details					
Project Name		Thurber Engineering, File# 30624			
Project Location		Ontario, Canada			
Borehole		BH21-2	BH21-2	BH21-2	
Sample No.		TW5	TW5	TW5	
Depth		20-22	20-22	20-22	
Sample Date		January 11, 2021	January 11, 2021	January 11, 2021	

Shearing Stages



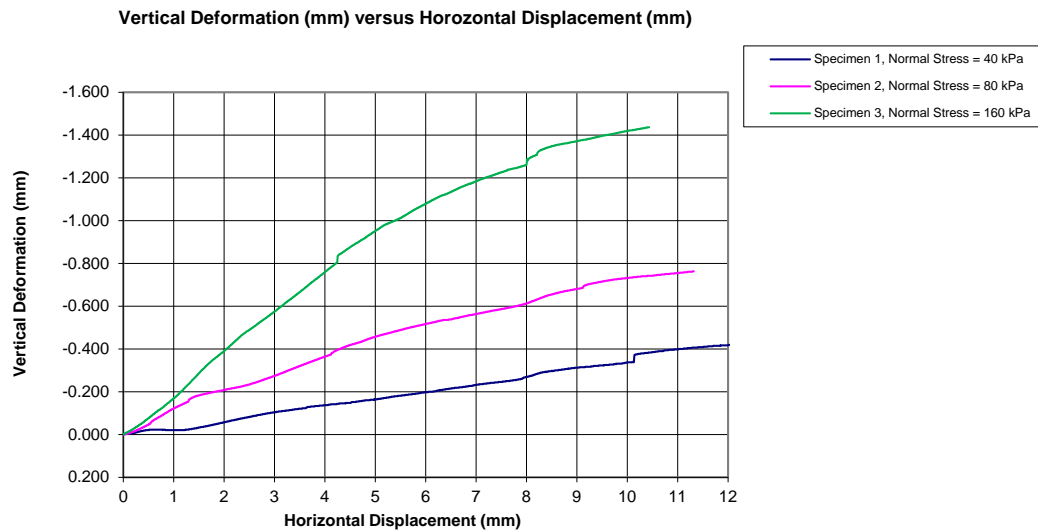


Stantec Consulting Ltd.

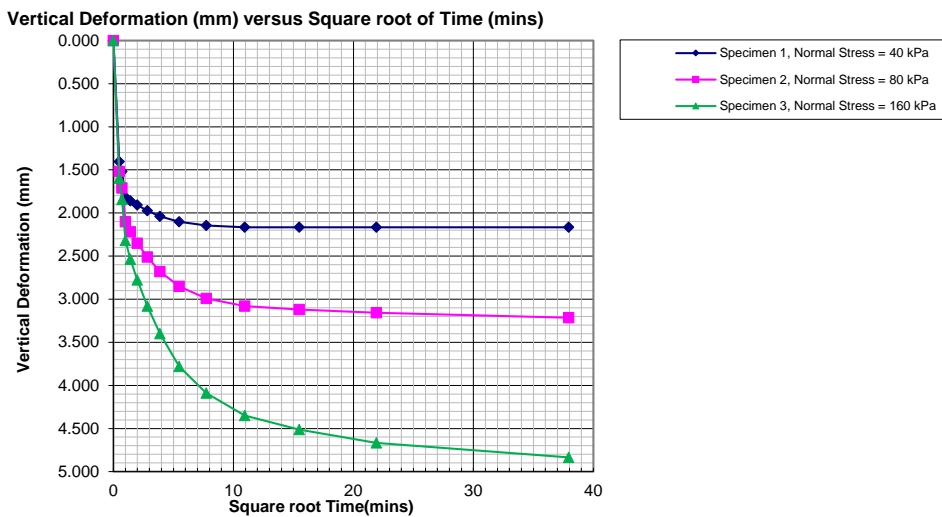
Direct Shear Test of Soils Under Consolidated Drained Conditions ASTM D3080/D3080M

Specimen Details		Specimen 1	Specimen 2	Specimen 3
Project Name	Thurber Engineering, File# 30624			
Project Location	Ontario, Canada			
Borehole		BH21-2	BH21-2	BH21-2
Sample No.		TW5	TW5	TW5
Depth	ft	20-22	20-22	20-22
Sample Date		January 11, 2021	January 11, 2021	January 11, 2021

Shearing Stage



Consolidation curves



Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

March 9, 2021
March 9, 2021

Date:
Date:

D. Boateng
R. Dey

Checked by:
Approved by:

Sample Details	Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW9	TW9	TW9
Depth	30-32 ft	30-32 ft	30-32 ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	4	5	6
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Soil Description & Classification

Silty clay, grey, varved, wet			
Specific Gravity of Solids	2.706	2.706	2.706
Additional Notes (unusual conditions or other information necessary to interpret the test results):			
One specific gravity test performed for all three specimens			
Specimen 4 & 5 were consolidated in stages until the stipulated effective consolidation stresses			
Consolidation stresses provided by client			
Departures from the test procedure outlined in ASTM D4767-11 (2020):			

Initial Specimen Conditions

Height	mm	140.0	140.0	140.0
Diameter	mm	70.0	70.0	70.0
Dry Unit Weight	Mg/m ³	1.14	0.98	0.98
Void Ratio		1.36	1.94	1.99
Water Content	%	49.85	71.69	73.47
Degree of Saturation	%	99.1	100.0	100.0
Method used for obtaining water content		Cuttings	Cuttings	Cuttings

Membrane Properties

Young's Modulus	kPa	1400	1400	1400
Thickness	mm	0.3	0.3	0.3

Filter-Paper Strip Properties

Load carried per unit length	kN/mm	0.00019	0.00019	0.00019
Specimen perimeter covered by strips	mm	220	220	220

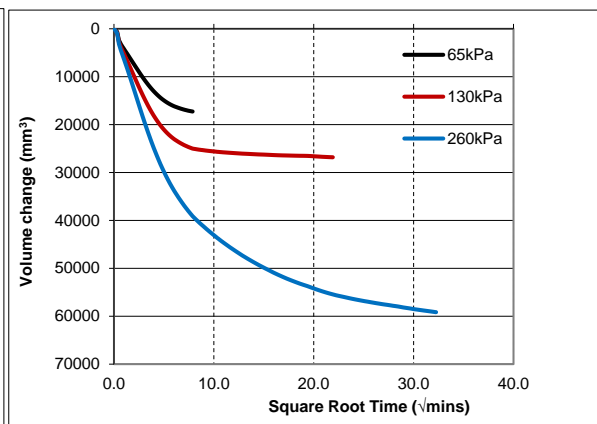
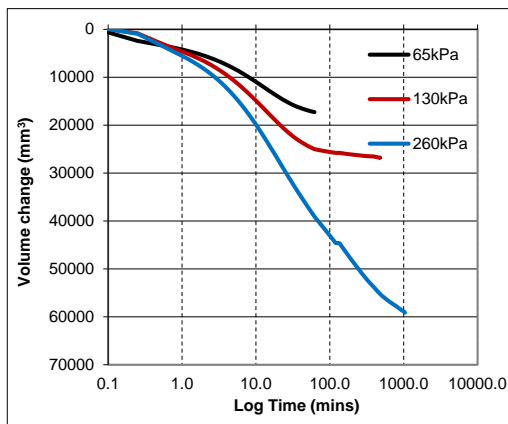
Consolidated Undrained Triaxial Compression Test for Cohesive Soils ASTM D4767 - 11 (2020)

Sample Details	Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW9	TW9	TW9
Depth	30-32 ft	30-32 ft	30-32 ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	4	5	6
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Test Setup	Specimen 4	Specimen 5	Specimen 6
Date Started	February 16, 2021	February 18, 2021	February 20, 2021
Date Finished	February 18, 2021	February 20, 2021	February 23, 2021
Top Drain Used	Yes	Yes	Yes
Base Drain Used	Yes	Yes	Yes
Side Drains Used (Filter-Paper Strips)	Yes	Yes	Yes
Pressure System Number	21706	21706	21706
Cell Number	21969	21969	21969

Measurement of Pore Pressure Parameter	Specimen 4	Specimen 5	Specimen 6
Cell Pressure Increment kPa	10.0	10.0	10.0
Cell Pressure at B determination kPa	100.0	100.0	100.0
Back Pressure at B determination kPa	90.0	90.0	90.0
Pore Pressure at B determination (initial) kPa	77.1	75.1	77.2
Pore Pressure at B determination (final) kPa	87.4	85.2	87.4
Pore Pressure Parameter B at 2 min	1.0	1.0	1.0
Method used for specimen saturation	Wet	Wet	Wet

End of Consolidation Stage	Specimen 4	Specimen 5	Specimen 6
Consolidation Stress kPa	65.0	130.0	260.0
Effective Consolidation Stress kPa	66.5	131.3	259.5
Total Back Pressure kPa	100.0	100.0	100.0
Time to 50 % primary consolidation min	7	18	107
Interpretation method used for t ₅₀	1	1	1
Dry Unit Weight Mg/m ³	1.18	0.96	1.02
Void Ratio	1.30	1.82	1.65
Water Content %	47.90	67.26	60.98
Degree of Saturation %	100.0	100.0	100.0
Cross-sectional Area, A _c mm ²	3736.2	3943.4	3709.0
Method used to determine Area, A _c	Method A	Method A	Method A

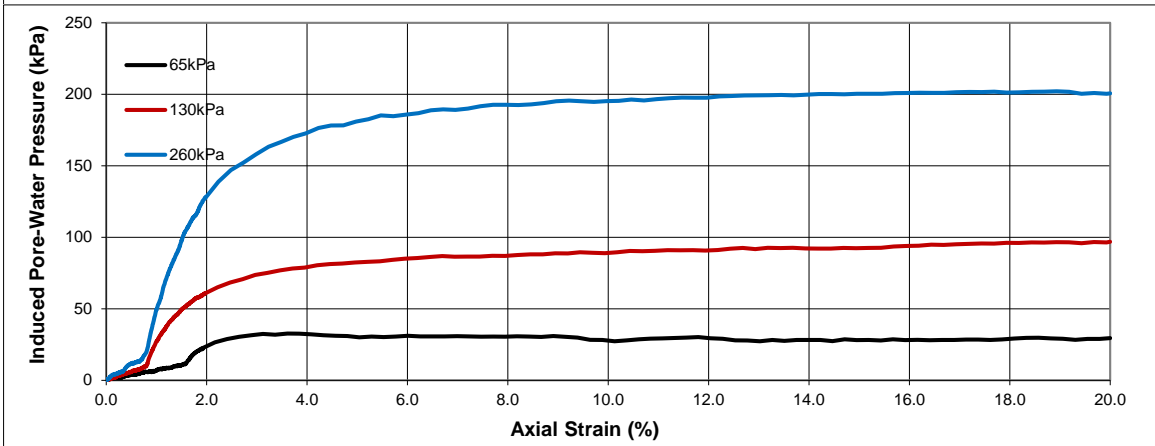
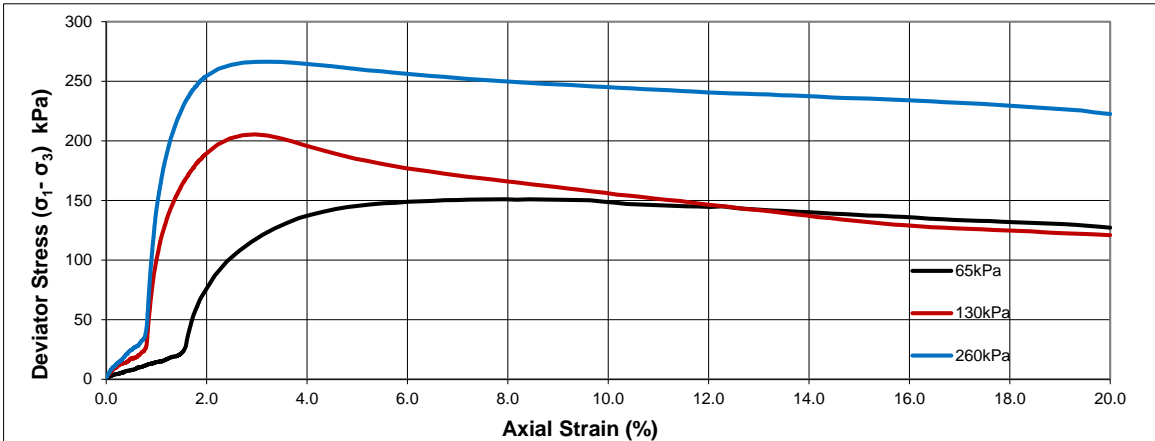


Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

Sample Details	Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW9	TW9	TW9
Depth	30-32 ft	30-32 ft	30-32 ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	4	5	6
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Shearing Stage			
Failure Criterion	20% Axial Strain	20% Axial Strain	20% Axial Strain
Rate of axial strain %/min	0.0166	0.0166	0.0166

Response at Failure			
Maximum Deviator Stress ($\sigma_1 - \sigma_3$) kPa	151.0	205.4	266.3
Axial Strain at ($\sigma_1 - \sigma_3$) maximum %	7.9	3.0	3.2
Max Effective Principal Stress Ratio (σ'_1 / σ'_3)	5.4	5.0	5.0
Deviator Stress at (σ'_1 / σ'_3) maximum kPa	150.7	172.7	237.1
Axial Strain at (σ'_1 / σ'_3) maximum %	8.9	6.7	14.2
Effective Major Principal Stress (σ'_1) kPa	185.5	256.9	363.0
Effective Minor Principal Stress (σ'_3) kPa	34.5	51.5	96.7
Values corrected for membrane?	Yes	Yes	Yes
Values corrected for filter-paper strips?	Yes	Yes	Yes



Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

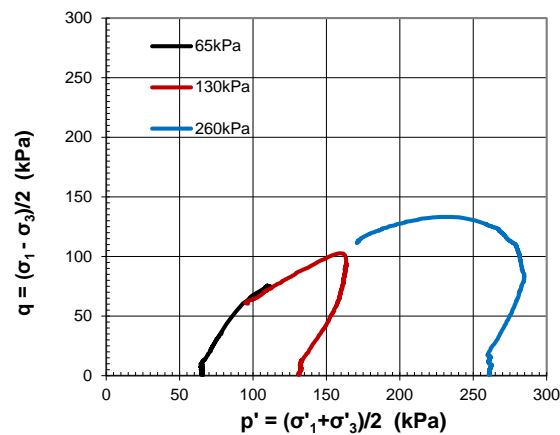
Specimen 4

Specimen 5

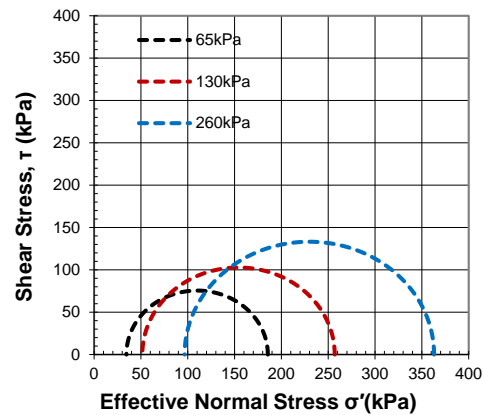
Specimen 6

Sample Details

Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW9	TW9	TW9
Depth	30-32 ft	30-32 ft	30-32 ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	4	5	6
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng



Mohr's Circles



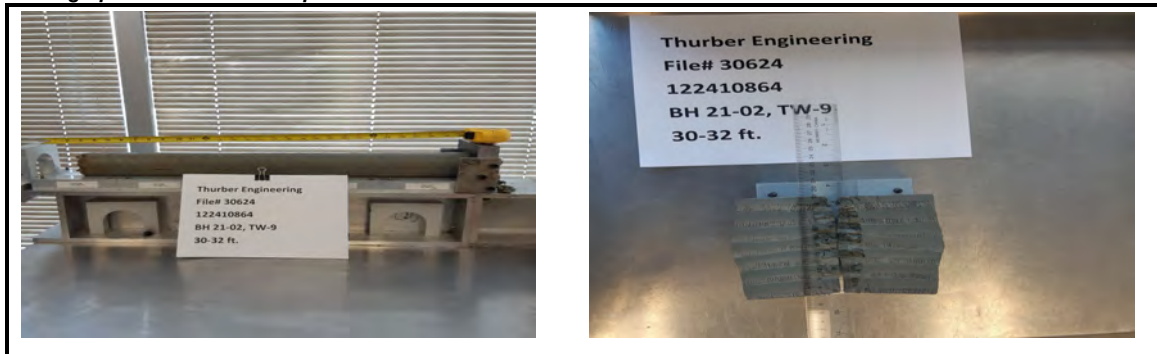
Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4767 - 11 (2020)

March 9, 2021
March 9, 2021

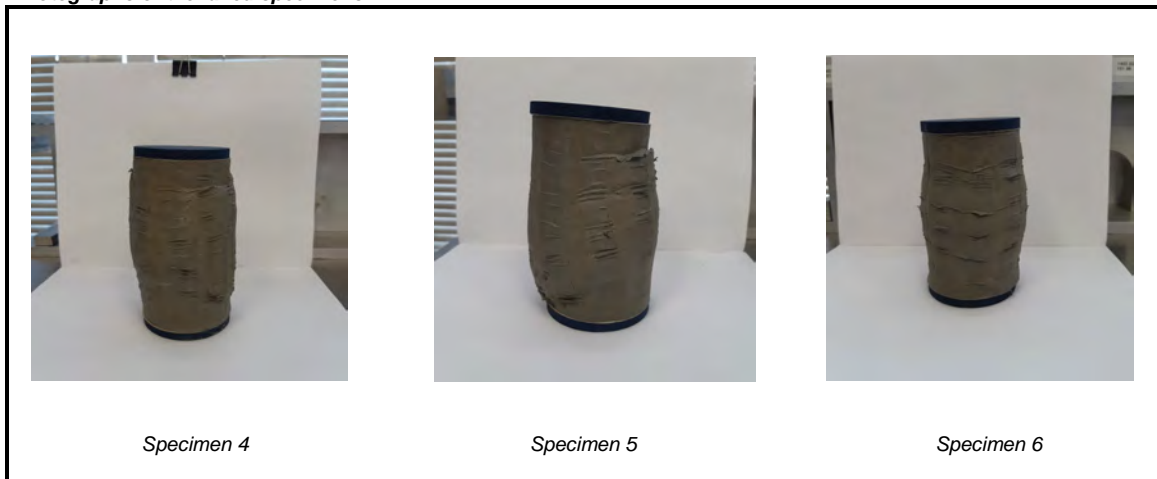
Checked by: D. Boateng
Approved by: R. Dey

Sample Details	Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample Number	TW9	TW9	TW9
Depth	30-32 ft	30-32 ft	30-32 ft
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021
Test Number	4	5	6
Technician Name	Daniel Boateng	Daniel Boateng	Daniel Boateng

Photographs of the extruded specimen and a sliced section



Photographs of the failed specimens



Direct Shear Test of Soils Under Consolidated Drained Conditions ASTM D3080/D3080M

March 9, 2021
March 9, 2021

Date: Date:
D. Boateng Rajib Dey

Prepared by:
Checked by:

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March 9, 2021

Filename:
Date:

Specimen Details	Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624		
Project Location	Ontario, Canada		
Borehole	BH21-2	BH21-2	BH21-2
Sample No.	TW10	TW10	TW10
Depth	35-37	35-37	35-37
Sample Date	January 11, 2021	January 11, 2021	January 11, 2021

Soil Description & Classification

Silty clay ,grey, varved, moist

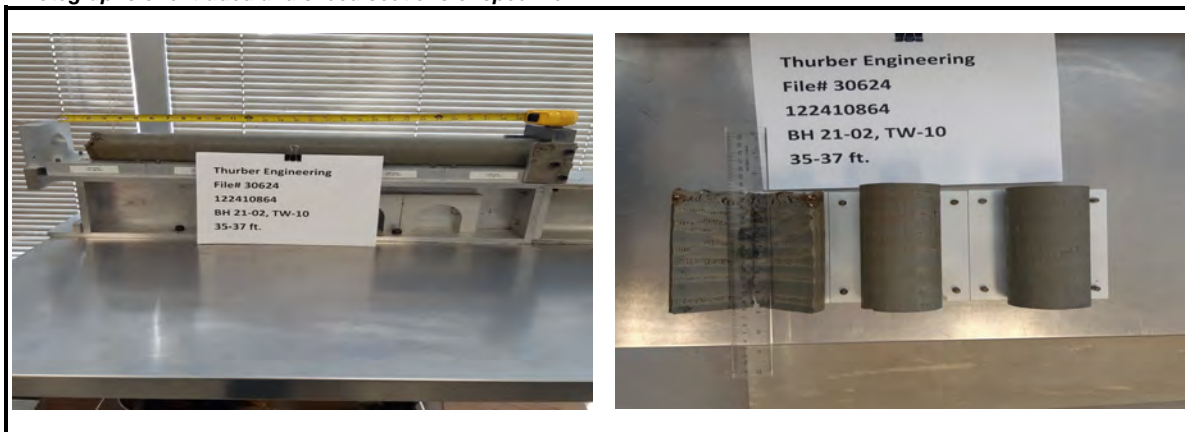
Initial Specimen Conditions

Height	mm	31.70	31.70	31.70
Diameter	mm	63.50	63.50	63.50
Mass	g	171.70	175.70	178.90
Dry Mass	g	113.70	122.43	115.69
Wet Density	Mg/m ³	1.71	1.75	1.78
Dry Density	Mg/m ³	1.13	1.22	1.15
Moisture Content	%	51.01	43.51	54.63
Degree of Saturation	%	100.0	93.3	97.8
Specific Gravity		2.706	2.706	2.706
Void Ratio		1.38	1.26	1.51

Final Specimen Conditions

Normal Stress	kPa	65	130	260
Time to Failure	min	186	195	414
Rate of Displacement	mm/min	0.024	0.024	0.024
Peak Shear Stress	kPa	32.8	65.7	129.6
H. Displacement-Peak	mm	4.6	4.8	10.1
Moisture Content	%	49.92	43.97	36.44

Photographs of extruded and sliced sections of specimen



Tests Notes:

1. Specimens inundated during the entire test
2. Tests specimen two & three were consolidated in stages of 24hrs to a maximum of 130 & 260 kPa respectively
3. Specific gravity of solids assumed for all three specimens
4. Consolidation stresses provided by client



Stantec Consulting Ltd.

Direct Shear Test of Soils Under Consolidated Drained Conditions ASTM D3080/D3080M

March 9, 2021
March 9, 2021

Date:
Date:

D. Boateng
Rajib Dey

Prepared by:
Checked by:

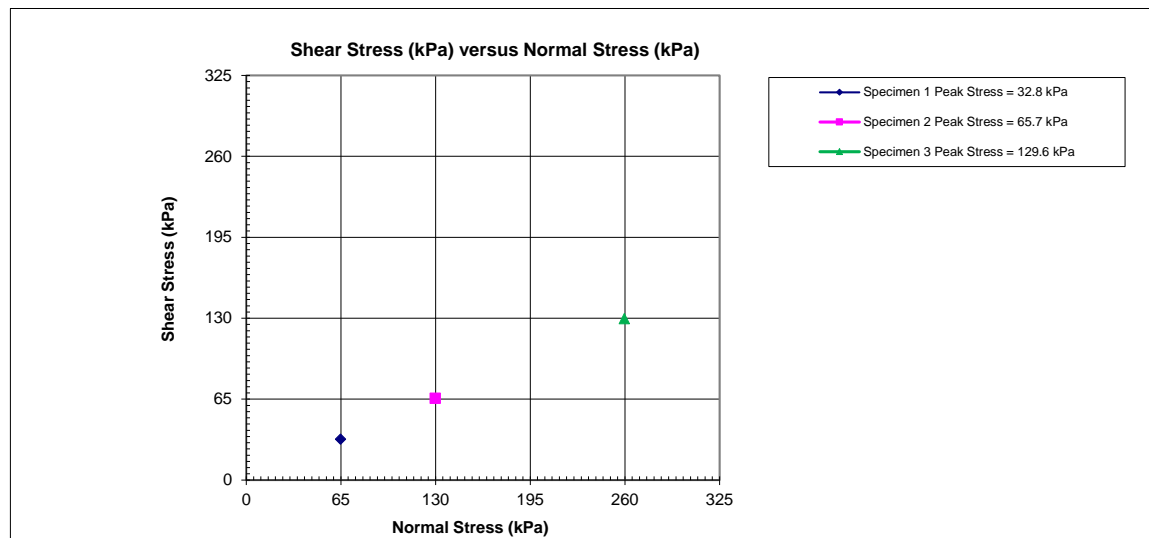
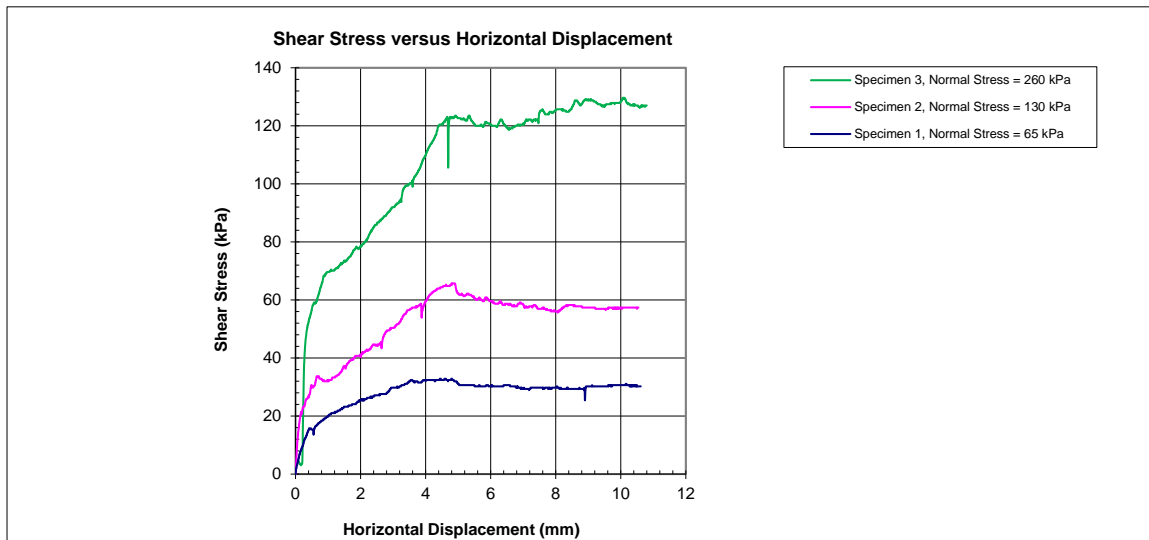
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March 9, 2021

Filename:
Date:

Specimen 4		Specimen 5		Specimen 6	
Specimen Details					
Project Name		Thurber Engineering, File# 30624			
Project Location		Ontario, Canada			
Borehole		BH21-2	BH21-2	BH21-2	
Sample No.		TW10	TW10	TW10	
Depth		35-37	35-37	35-37	
Sample Date		January 11, 2021	January 11, 2021	January 11, 2021	

Shearing Stages



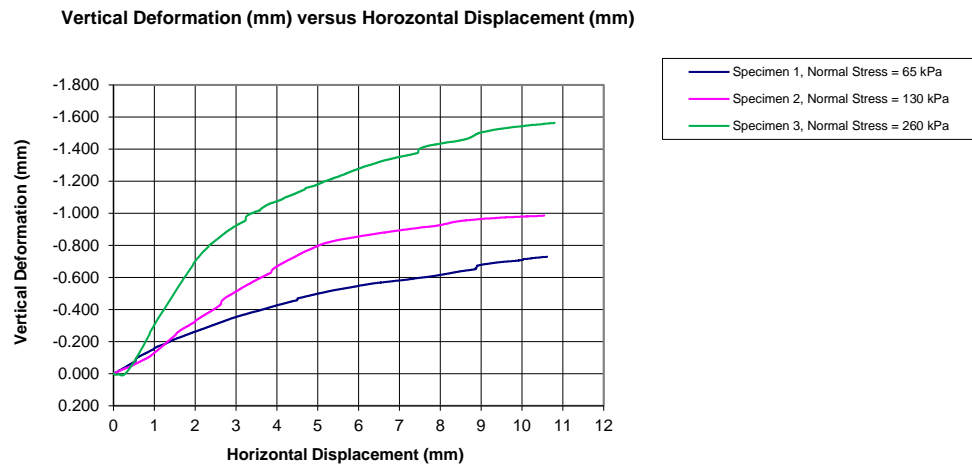


Stantec Consulting Ltd.

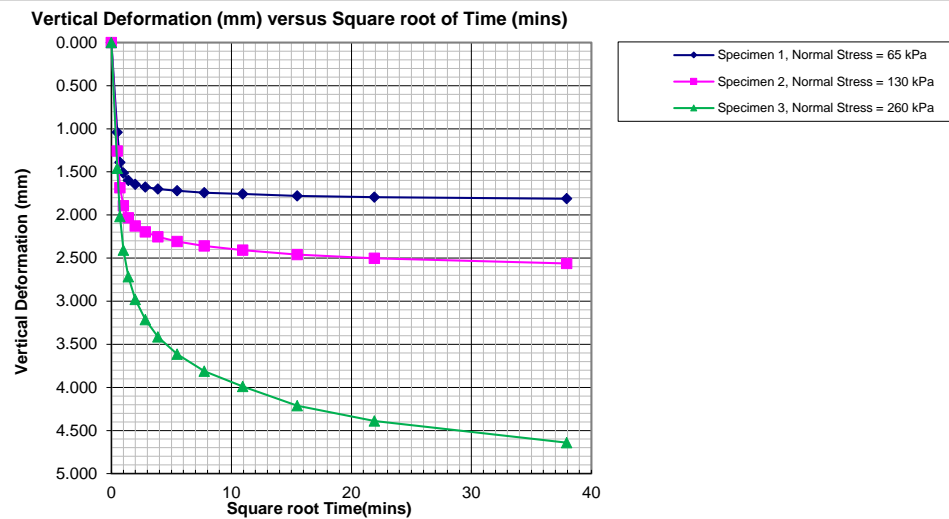
Direct Shear Test of Soils Under Consolidated Drained Conditions ASTM D3080/D3080M

Specimen Details		Specimen 4	Specimen 5	Specimen 6
Project Name	Thurber Engineering, File# 30624			
Project Location	Ontario, Canada			
Borehole	BH21-2			
Sample No.	TW10			
Depth	35-37			
Sample Date	January 11, 2021			

Shearing Stage



Consolidation curves



1-Mar

Date

Checked By Rajib Dey

18-Feb

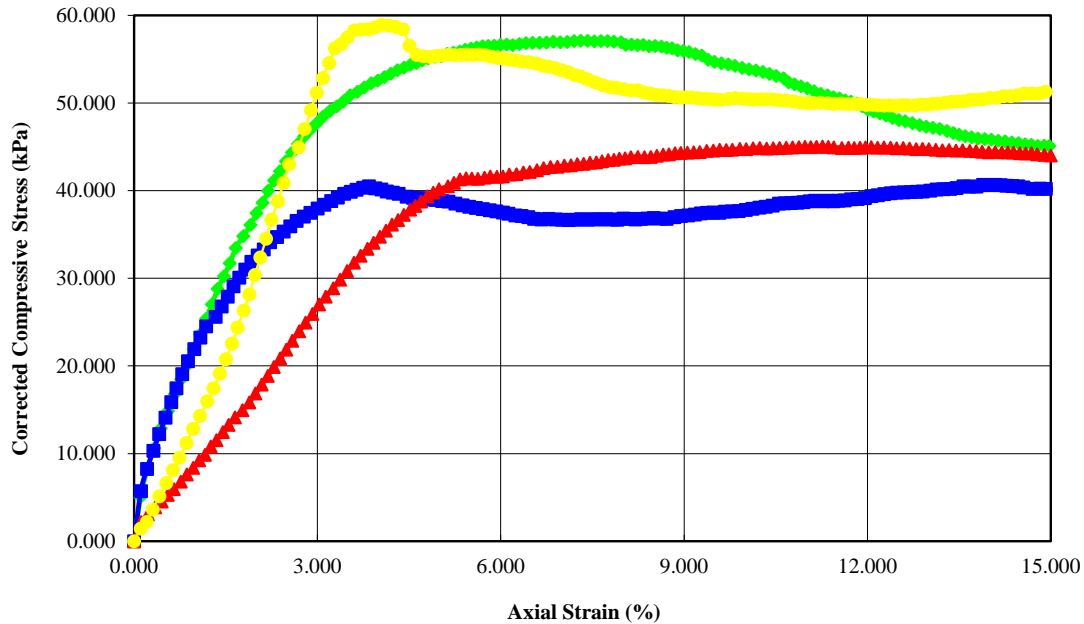
Date

Computed By Daniel Boateng

17-Feb-21

Tested By Daniel Boateng

Compressive Stress Axial Strain Curve



Before Test	BH21-2			
	TW3 @ 15-17'	TW6 @22½-24½'	TW7 @ 25-27'	TW8 @ 27½-29½'
Water Content (%)	50.56	43.66	45.52	46.34
Dry Density (g/cm3)	1.122	1.220	1.188	1.191
Saturation (%)	96.02	95.96	95.43	98.52
Void Ratio	1.44	1.25	1.31	1.27
Diameter (mm)	70.000	70.000	70.000	70.000
Height (mm)	151.950	151.950	151.950	151.990
Test Data				
Unconfined Strength (kPa)	57.102	40.484	45.033	58.910
Undrained Shear Strength (kgf/cm^2)	0.291	0.206	0.230	0.300
Undrained Shear Strength (kPa)	28.551	20.242	22.517	29.455
Rate of Strain (mm/min)	1.900000	1.900000	1.900000	1.900000
Strain at Failure (%)	7.42	3.843	11.27	4.05
Description				
Project Information		Specimen Description		
Project Num	122410864	TW3 @ 15-17'	Silty clay, brown/grey, friable, moist	
Project	Thurber Engineering, File# 30624	TW6 @ 22½-24½'	Silty clay, grey, varved, moist	
Sampling Date	January 11, 2021	TW7 @ 25-27'	Silty clay, grey, varved, moist	
Sample #	BH21-2	TW8 @ 27½-29½'	Silty clay, grey, varved, moist	
Client	Thurber Engineering	Test Variables		
		Specific Gravity of	2.740 assumed for TW 3, 6, 7	
		Specific Gravity of	2.706 assumed for TW 8	



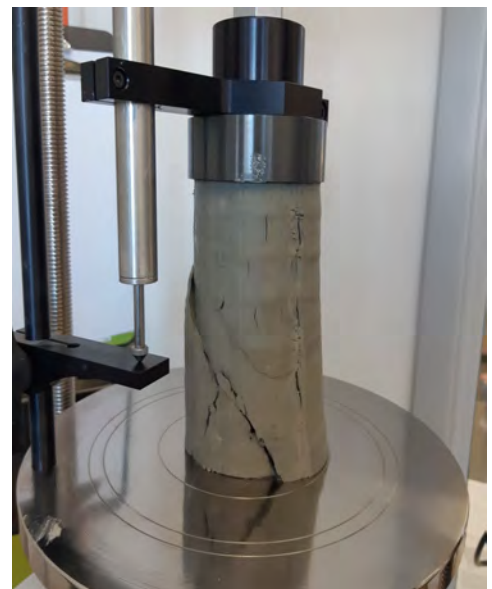
Project No.: 122410864

Project Name: Thurber Engineering, File# 30624


Photo Log

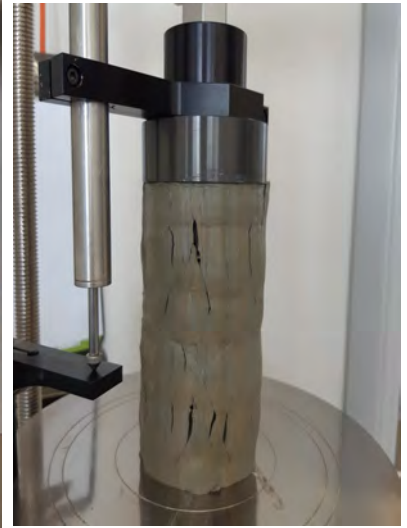
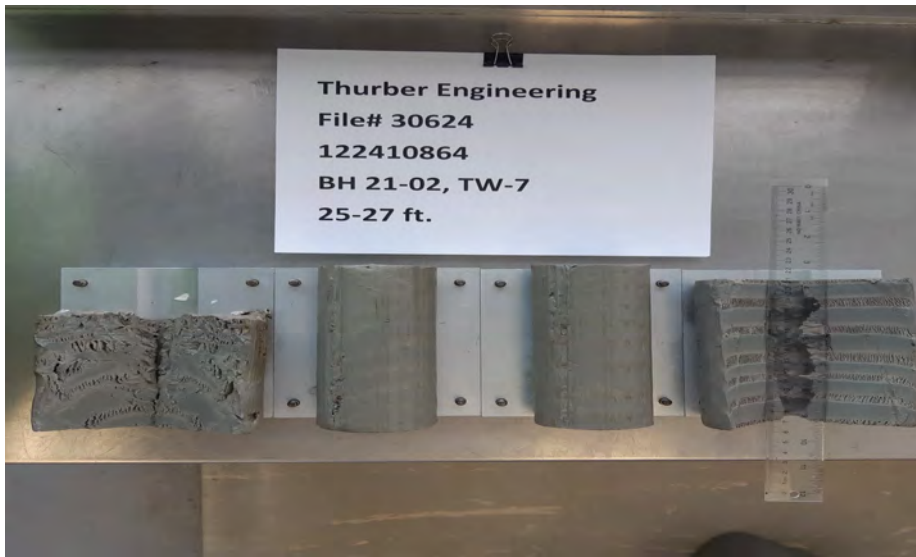


Test No.: 1 Borehole: BH21-2 TW3 Depth: 15 – 17 ft

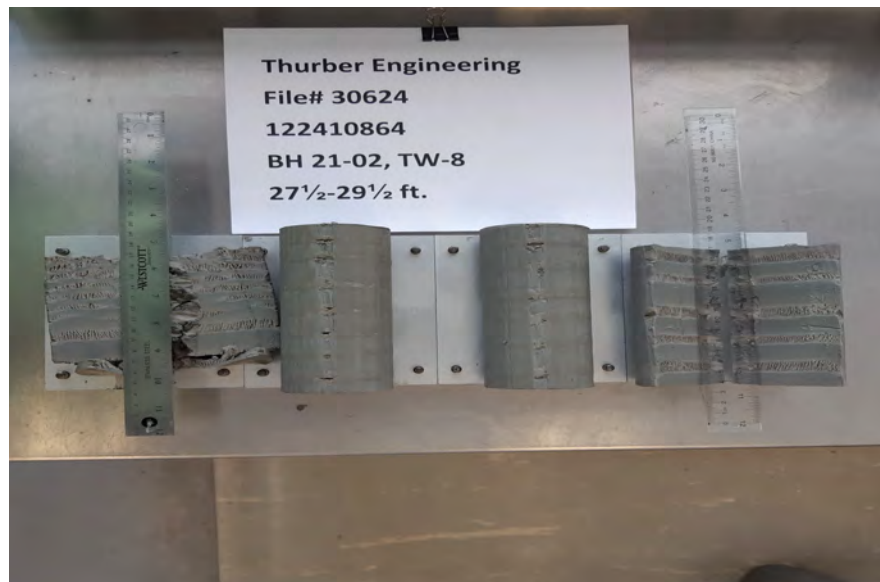


Test No.: 2 Borehole: BH 21-2 TW6 Depth: 22½ – 24½ ft

	Project No.: 122410864 Project Name: Thurber Engineering, File# 30624	Photo Log
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Test No.:	3	Borehole:	BH21-2 TW7	Depth:	25 – 27 ft
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Test No.:	4	Borehole:	BH21-2 TW8	Depth:	27½ – 29½ ft
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1-Mar

Date

Checked By **Rajib Dey**

22-Feb

Date

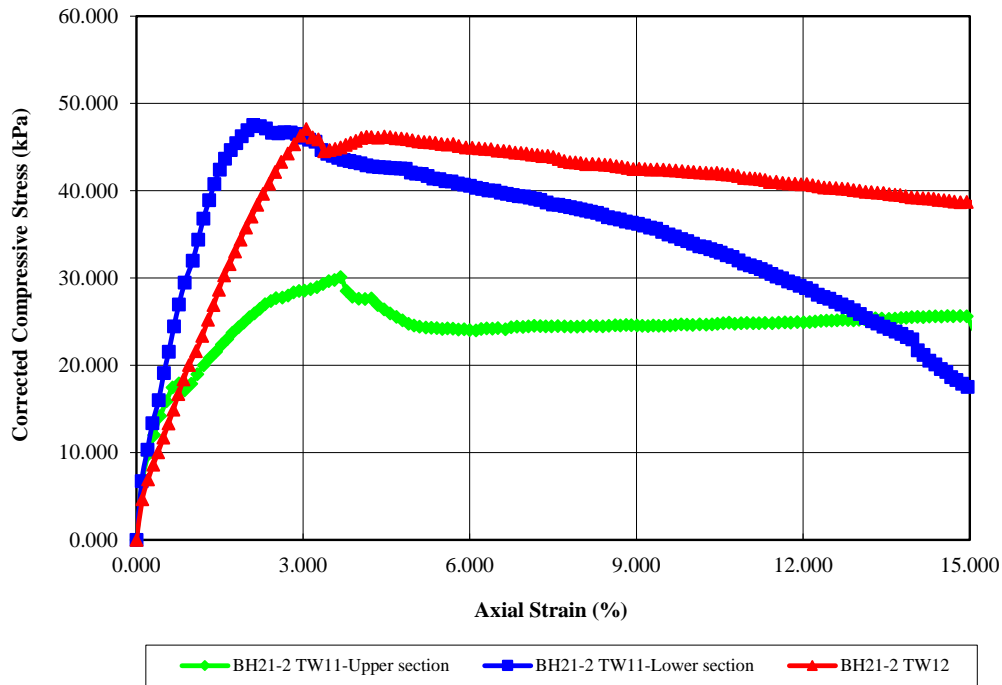
Computed By **Daniel Boateng**

19-Feb


Date

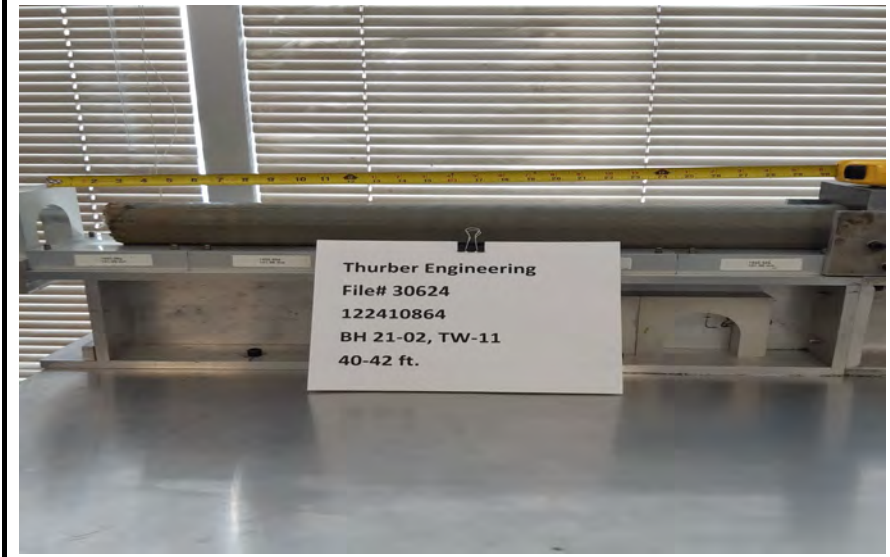
Tested By **Daniel Boateng**

Compressive Stress Axial Strain Curve



Before Test	Specimen			
	TW1 1 @ 40-41'	TW 11 @ 41-42'	TW 12 @ 45-47'	
Water Content (%)	48.40	48.16	46.56	
Dry Density (g/cm3)	1.131	1.154	1.175	
Saturation (%)	94.00	96.90	96.64	
Void Ratio	1.39	1.34	1.30	
Diameter (mm)	70.000	70.000	70.000	
Height (mm)	151.990	151.980	151.990	
Test Data				
Unconfined Strength (kPa)	30.119	47.543	47.080	
Undrained Shear Strength (kgf/cm^2)	0.154	0.242	0.240	
Undrained Shear Strength (kPa)	15.059	23.771	23.540	
Rate of Strain (mm/min)	1.900000	1.900000	1.900000	
Strain at Failure (%)	3.67	2.10	3.06	
Description				
Project Information		Specimen Description		
Project Num	122410864	TW1 1@ 40-41'	Silty clay, gray, varved, moist	
Project	Thurber Engineering, File# 30624	TW 11 @ 41-42'	Silty clay, gray, varved, moist	
Sampling Date	January 11, 2021	TW 12 @ 45-47'	Silty clay, gray, varved, moist	
Sample #	BH 21-2			
Client	Thurber Engineering	Test Variables		
		Specific Gravity of	2.706 assumed for TW11 & TW12	
Remarks	Two tests conducted on TW 11- Upper & Lower sections of Tube			

	Project No.: 122410864	Photo Log
	Project Name: Thurber Engineering, File# 30624	



Test No.:	5	Borehole: BH21-2 TW11	Depth: 40'4" – 40'10"
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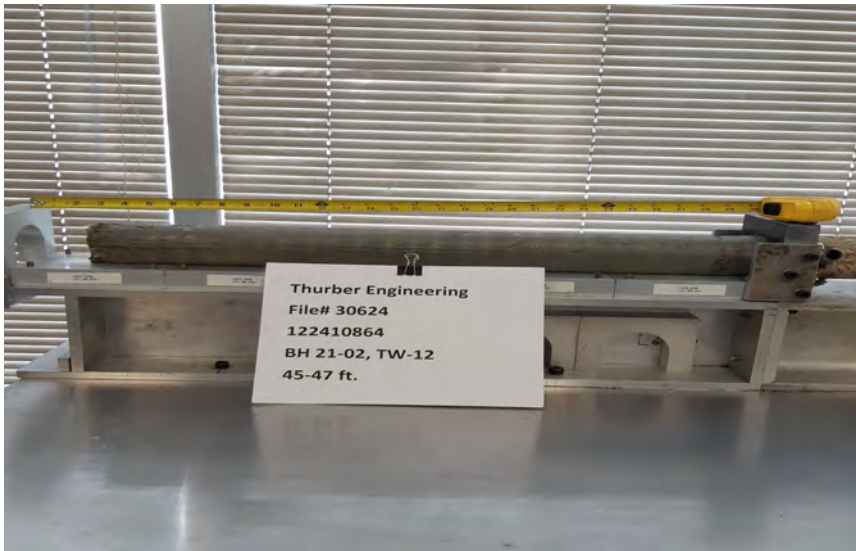
Test No.:	6	Borehole: BH21-2 TW11	Depth: 41'4" – 41'10"
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Project No.: 122410864

Project Name: Thurber Engineering, File# 30624

Photo Log



Test No.: 7

Borehole: BH21-2 TW12

Depth: 45 – 47 ft



Test No.: 7

Borehole: BH21-2 TW12

Depth: 45 – 47 ft



Appendix C.3
Rock Core Photos

Borehole INC21-1
Runs 1 to 2
Elevation 184.4 m to 182.0 m

Run 1 Start
Elev. 184.4 m

Run 1 End
Elev. 183.5 m

Run 2 Start
Elev. 183.5 m

Run 2 End
Elev. 182.0 m



Borehole INC21-4
Runs 1 to 2
Elevation 184.5 m to 182.0 m

Run 1 Start
Elev. 184.5 m

Run 1 End
Elev. 183.5 m

Run 2 Start
Elev. 183.5 m

Run 2 End
Elev. 182.0 m





Appendix D.

Site Photographs and Historical Aerial Photographs



Photo 1: Aerial image from LGL Limited memo (dated November 18, 2020) showing the extent of the landslide on November 10, 2020. The head scarp of the slide has since retrogressed further to the southeast.



Photo 2: View of the landside from the toe looking up towards the head scarp (looking southeast).

December 4, 2020



Side scarp from a previous landslide

Photo 3: General view of slide debris, looking west, showing varved clay in the foreground and a old side scarp from a previous landslide.

December 4, 2020



Photo 4: View of original slide scar, looking west, which is locally steeper with an angle of approximately 40 degrees. Retrogression can be seen above the original failure.

December 4, 2020



Photo 5: View showing slump blocks, looking north from above the head scarp.

December 4, 2020



Photo 6: View showing the creek at the toe of slope cutting through the slide debris, looking northeast.

December 4, 2020



Photo 7: View looking southwest from the toe of the current failure showing the topography to the west, including a bowl-like topography indicative of a historic landslide and a more recent side scarp from a previous smaller-scale failure that likely overlapped the current failure.
December 4, 2020

Historic landslide to the west of the present failure



Photo 8: Panoramic view of the landslide, looking northeast to southeast. Bowl-like topography to the west is likely a remnant of a historic landslide.

December 4, 2020



Photo 9: Panoramic view of the landslide, looking east to west, from the toe.

December 4, 2020



Photo 10: Looking west showing a recent landslide on the north slope of the valley, which has dammed the creek. The slide is approximately 150 m downstream of the current failure.

December 4, 2020



Photo 11: View looking southeast at recent landslide.

January 5, 2021



Photo 12: Monument on rockfill slope.

January 5, 2021



Photo 13: Recent landslide on the north slope of the valley.

January 12, 2021



Photo 14: Vibrating wire piezometer upon installation.

January 12, 2021



Photo 15: Drilling operations.

January 14, 2021



Photo 16: Vibrating wire piezometers installed in January, 2021.

January 20, 2021



Photo 17: Monitoring well MW 21-3 installed in January, 2021.

January 20, 2021



Photo 18: View of Site looking east.

January 20, 2021



Photo 19: View looking north showing recent landslide on the north slope of the valley.

January 20, 2021



December 4, 2020



August 21, 2021



December 4, 2020



August 21, 2021



December 4, 2020



August 21, 2021



December 4, 2020



August 21, 2021



August 21, 2021



August 21, 2021





August 21, 2021



August 21, 2021



August 21, 2021



August 21, 2021



August 21, 2021



August 21, 2021

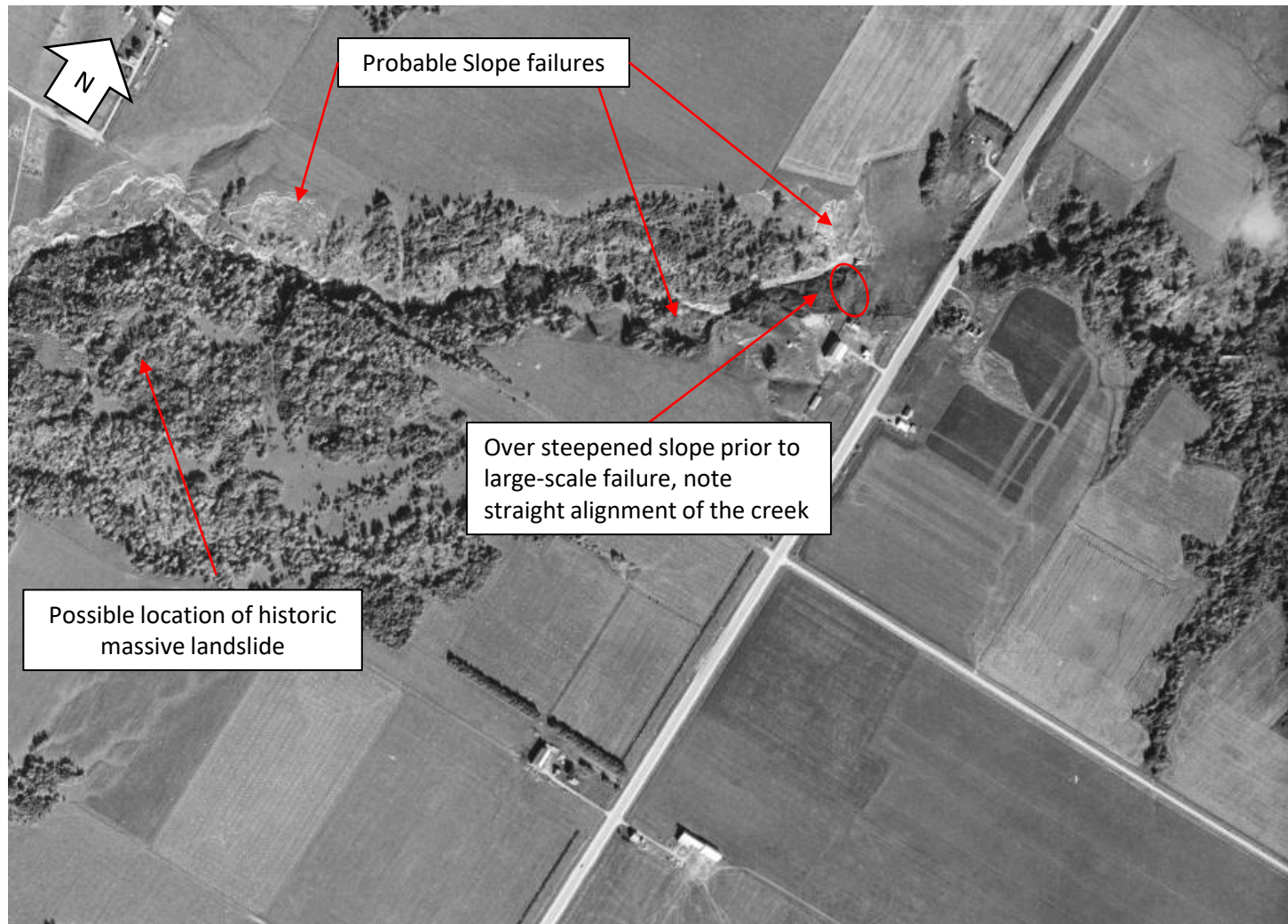


August 21, 2021



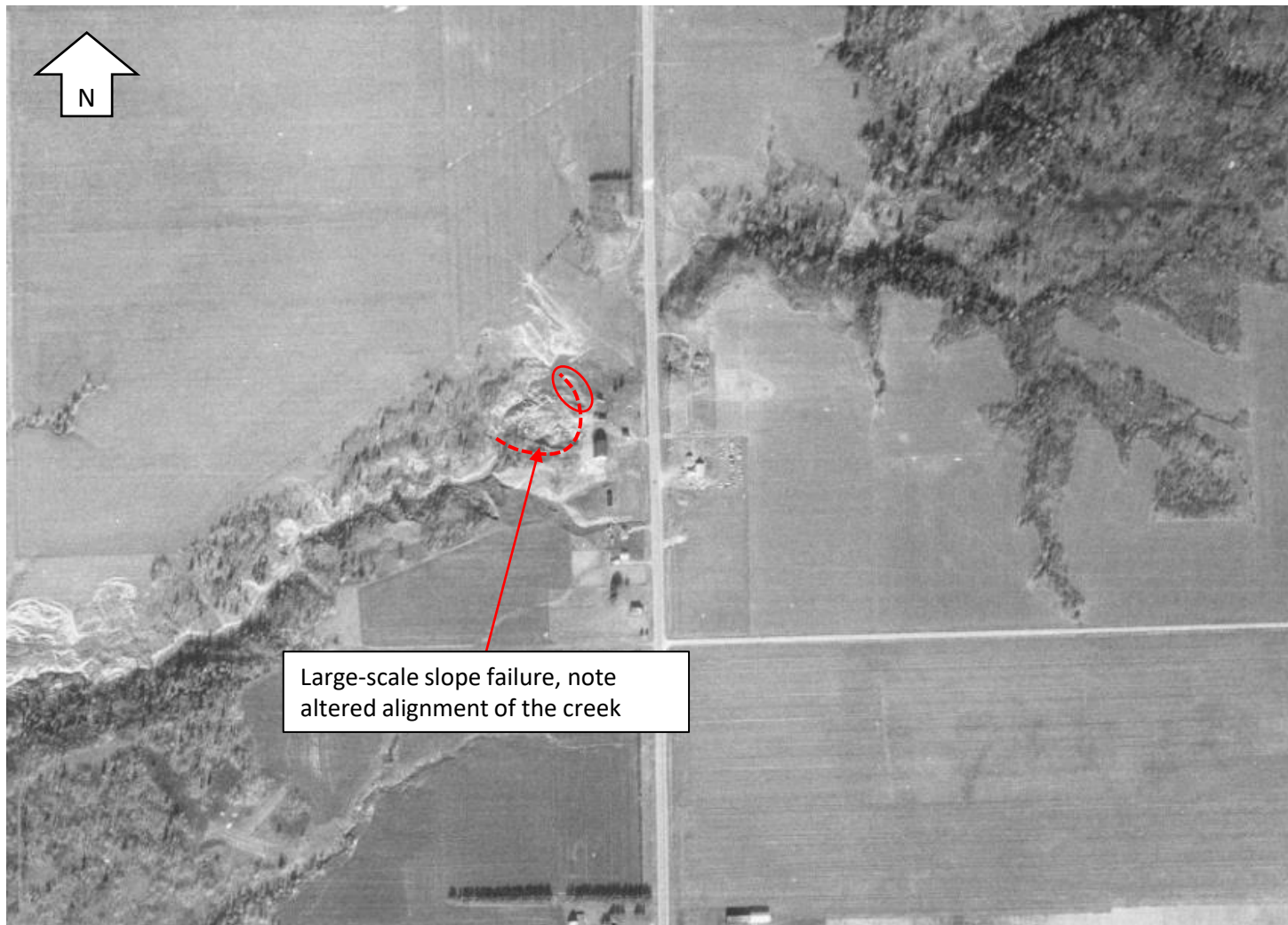
1951 Aerial Photograph

Calamity Creek Slope Failure Investigation
Highway 11, 2.9 km North of Highway 65 Junction
New Liskeard, Ontario



1963 Aerial Photograph

Calamity Creek Slope Failure Investigation
Highway 11, 2.9 km North of Highway 65 Junction
New Liskeard, Ontario



Large-scale slope failure, note altered alignment of the creek

1971 Aerial Photograph

Calamity Creek Slope Failure Investigation
Highway 11, 2.9 km North of Highway 65 Junction
New Liskeard, Ontario



1980 Aerial Photograph

Calamity Creek Slope Failure Investigation
Highway 11, 2.9 km North of Highway 65 Junction
New Liskeard, Ontario



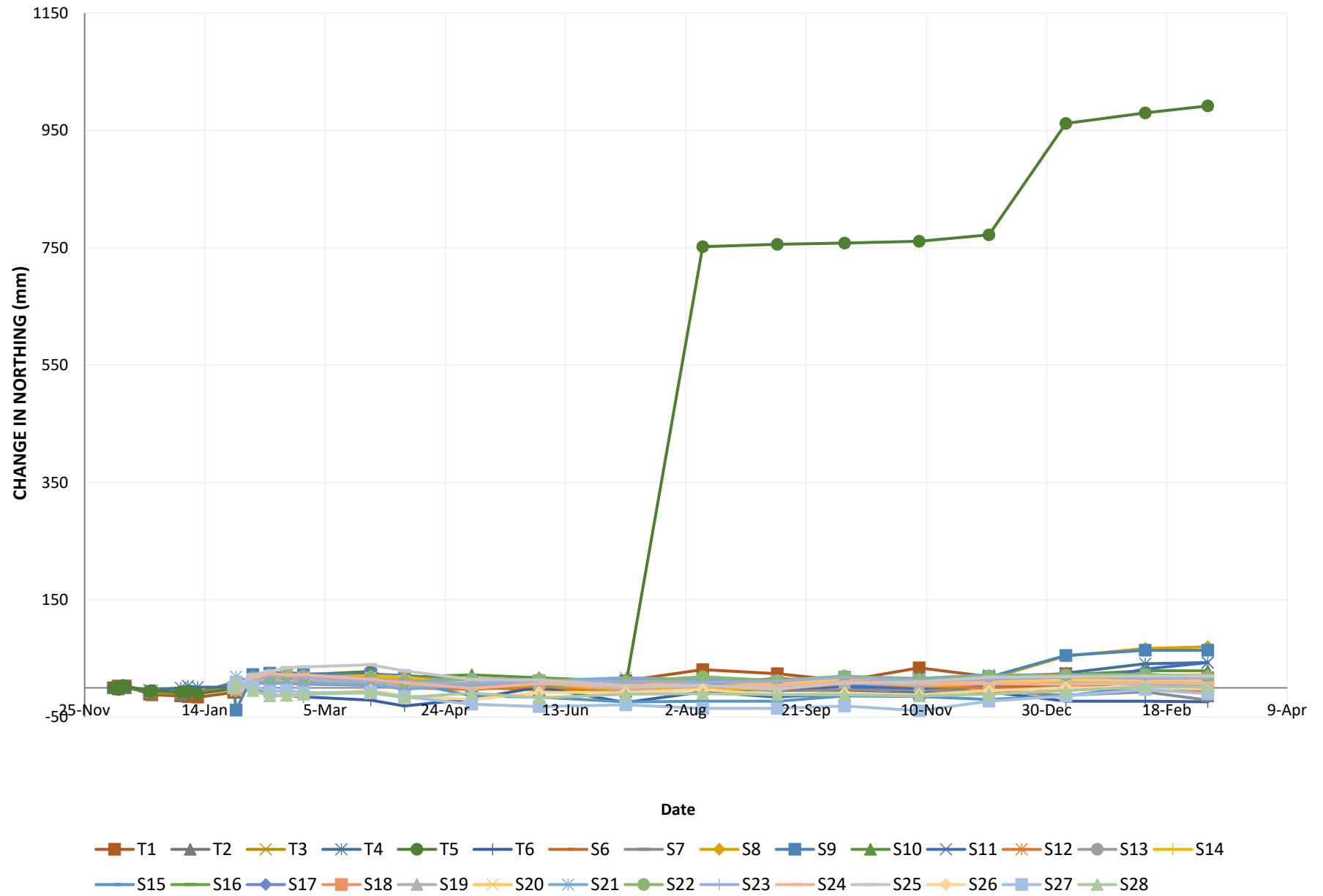
1994 Aerial Photograph

Calamity Creek Slope Failure Investigation
Highway 11, 2.9 km North of Highway 65 Junction
New Liskeard, Ontario

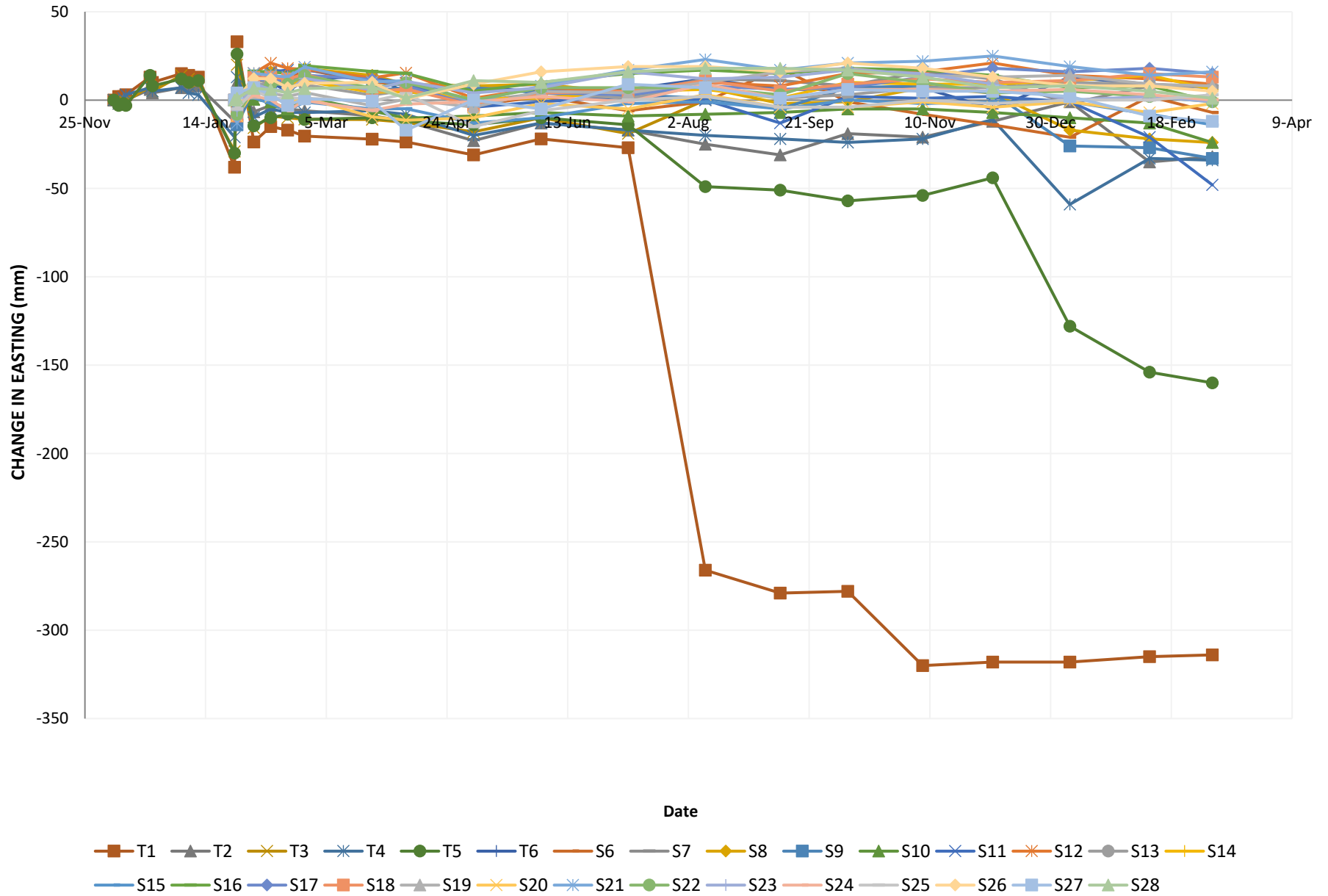


Appendix E.
Slope Monitoring Results

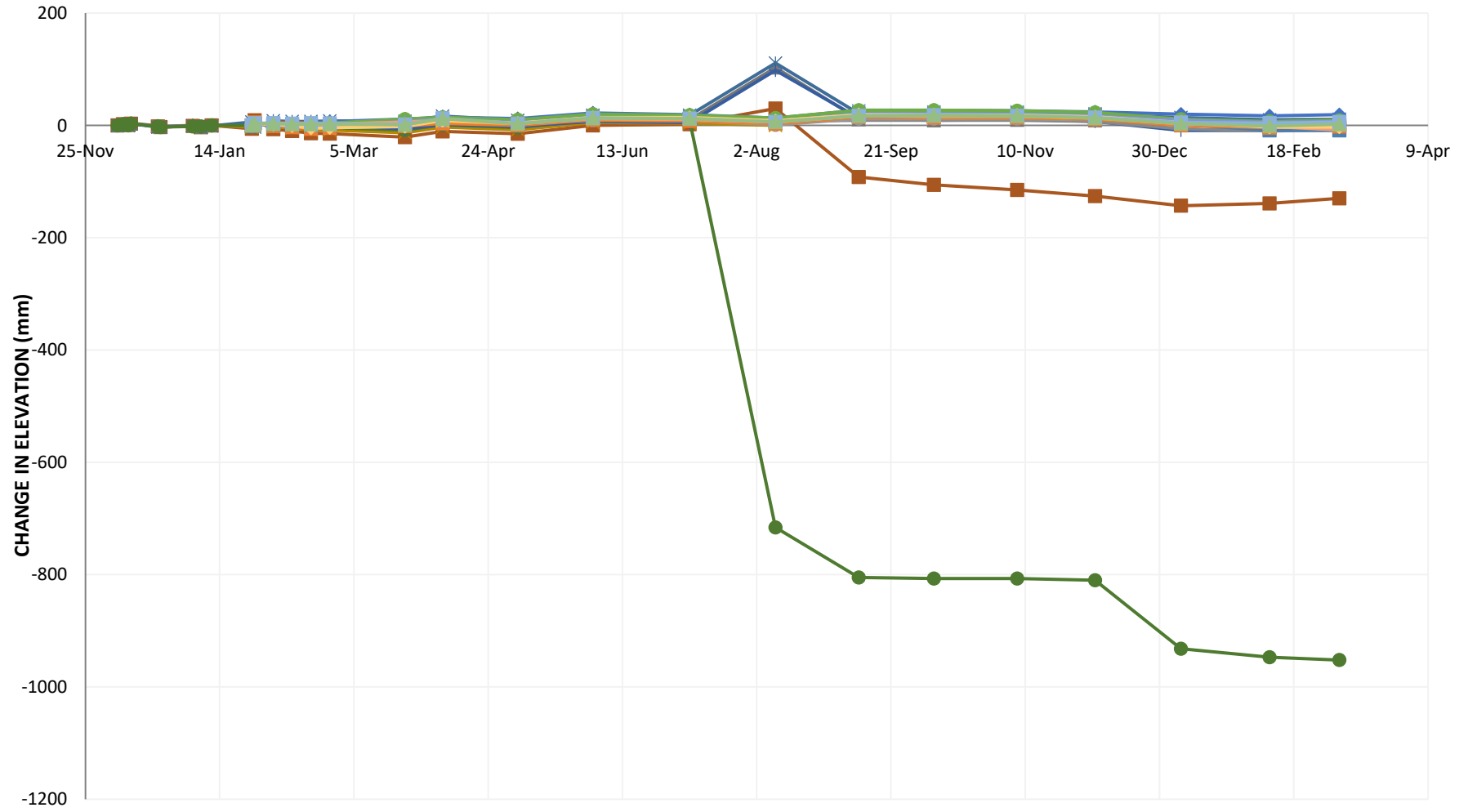
Change in Northing



Change in Easting



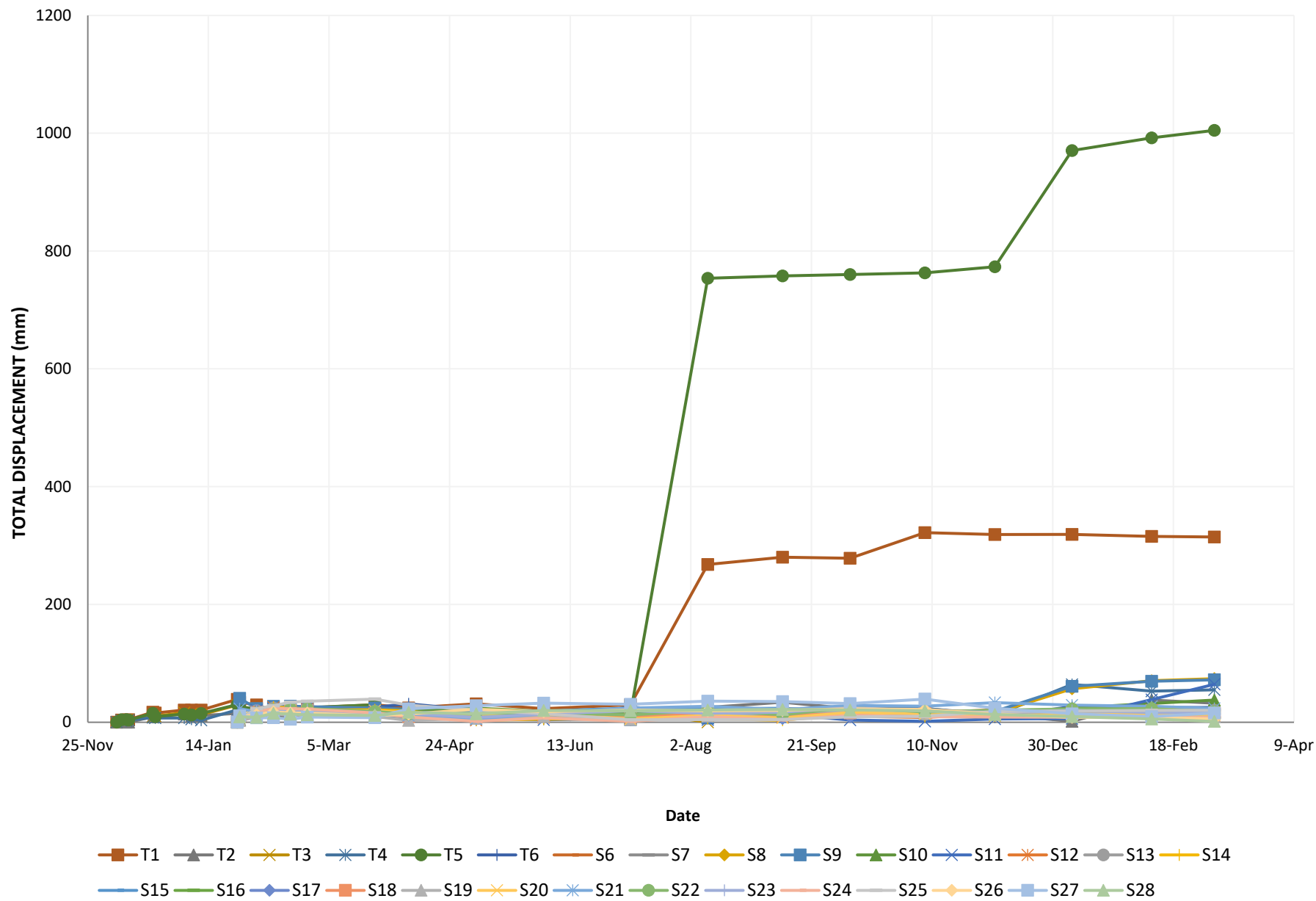
Elevation Monitoring



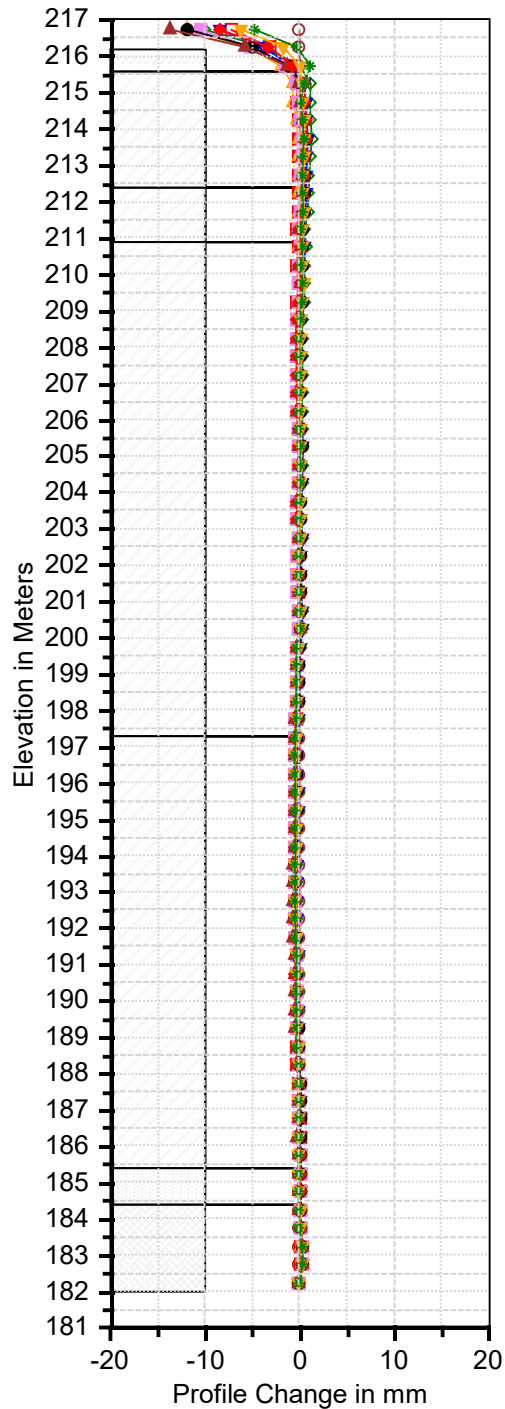
Date

T1 T2 T3 T4 T5 T6 S6 S7 S8 S9 S10 S11 S12 S13 S14
 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24 S25 S26 S27 S28

Total Displacement Monitoring

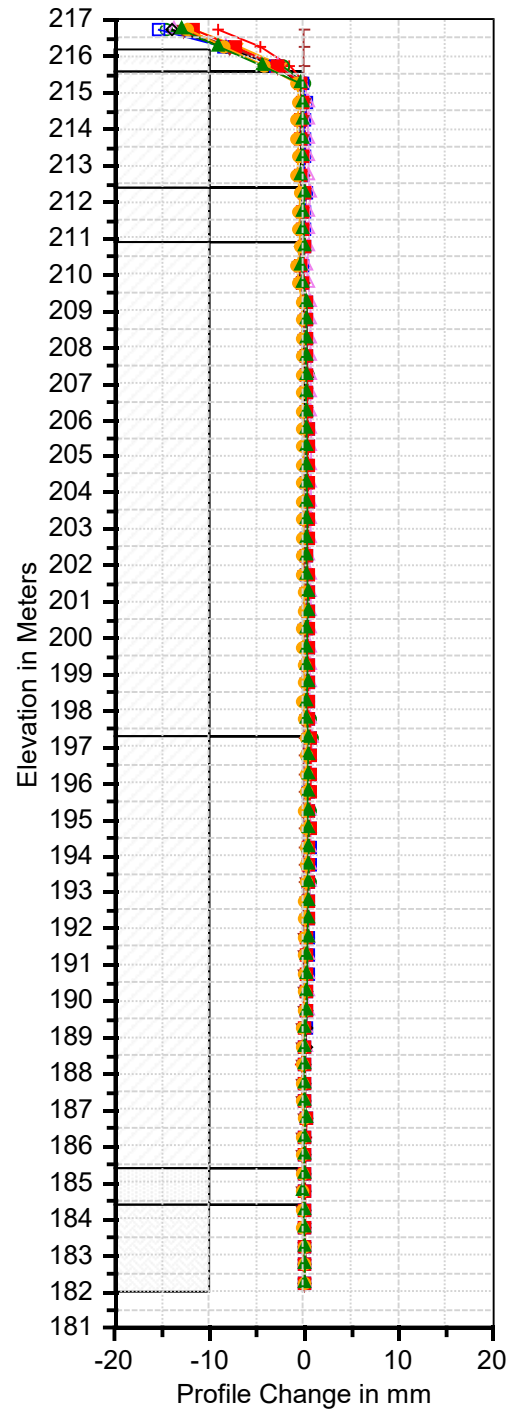


Calamity 21-1N (Downslope)



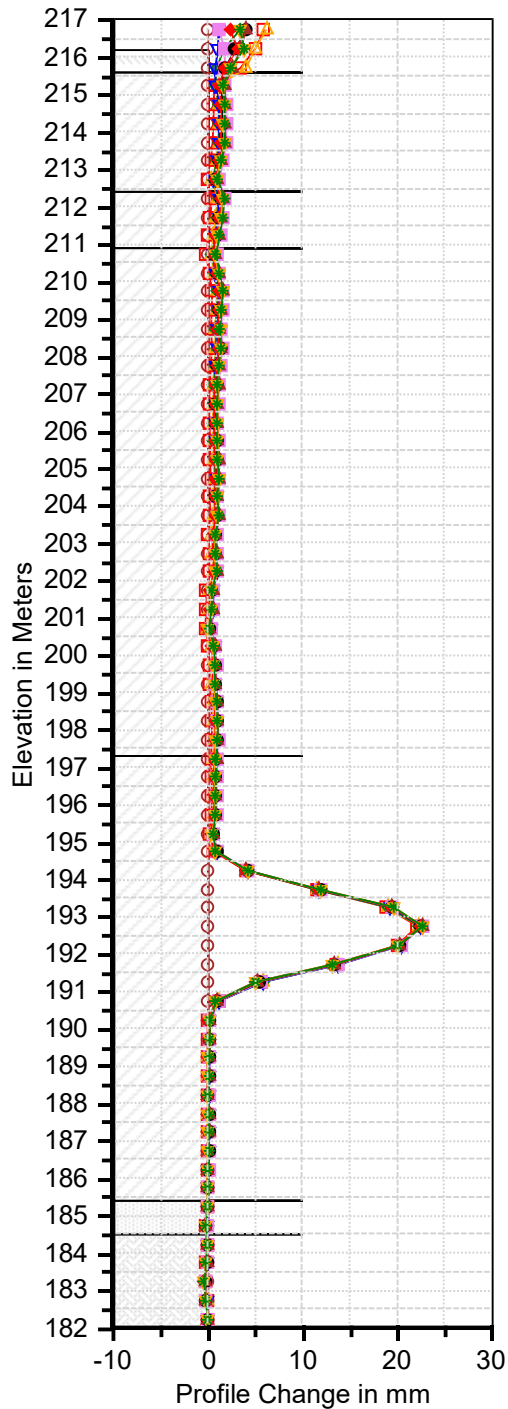
1/18/2021 6/2/2021 7/8/2021
 8/9/2021 9/8/2021 10/7/2021
 11/8/2021 12/6/2021 1/7/2022
 2/9/2022 3/7/2022

Calamity 21-1N (Cross Slope)



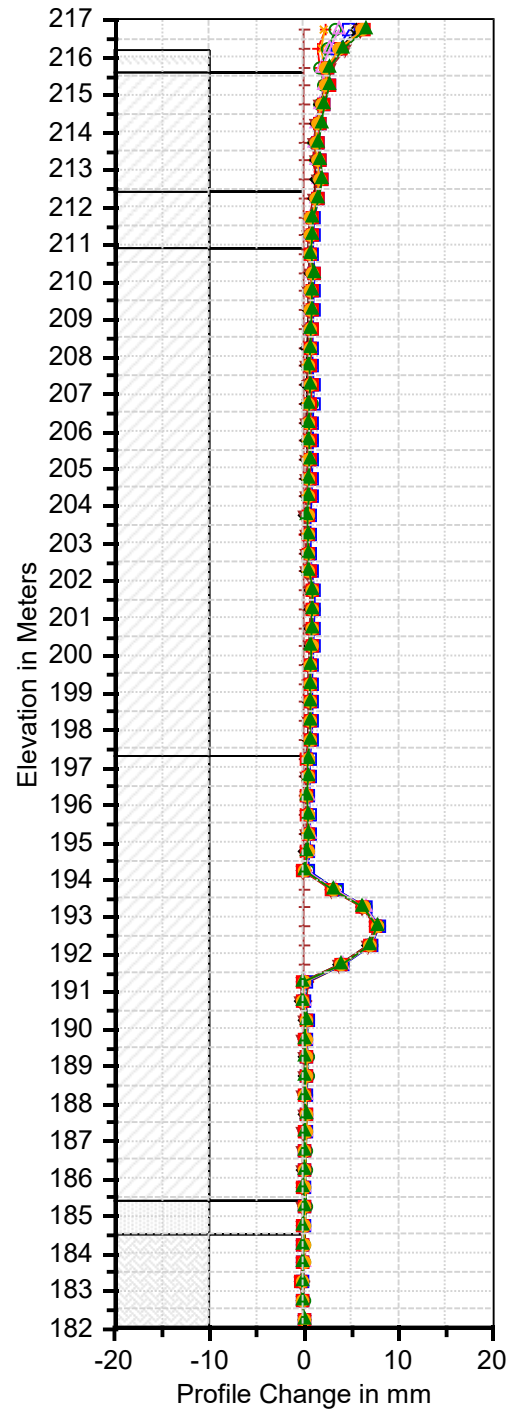
1/18/2021 6/2/2021 7/8/2021
 8/9/2021 9/8/2021 10/7/2021
 11/8/2021 12/6/2021 1/7/2022
 2/9/2022 3/7/2022

Calamity 21-4N (Downslope)



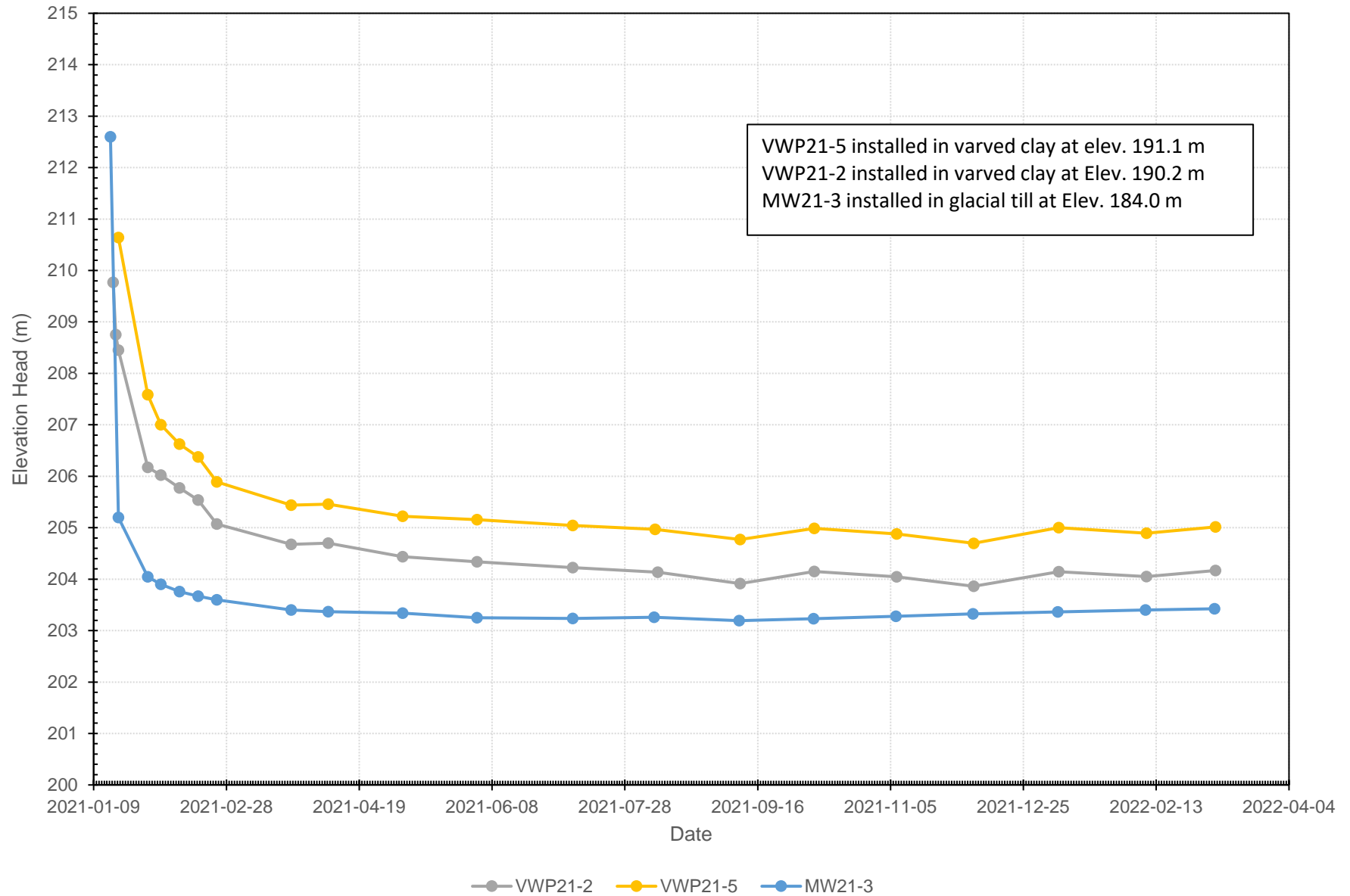
1/19/2021 4/7/2021 5/5/2021
 6/2/2021 7/8/2021 8/9/2021
 9/8/2021 11/8/2021 1/27/2022
 2/9/2022 3/7/2022

Calamity 21-4N (Cross Slope)



1/19/2021 4/7/2021 5/5/2021
 6/2/2021 7/8/2021 8/9/2021
 9/8/2021 11/8/2021 1/27/2022
 2/9/2022 3/7/2022

Vibrating Wire Piezometer Data - Elevation Head vs Time Highway 11 / Calamity Creek Slope Failure





Appendix F.

Factual Subsurface Information from GEOCREES Reports

RECORD OF BOREHOLE No 1

1 of 2

METRIC


G.W.P. 5159-12-00 LOCATION Coords: E:404593.1 N:5269457.4 ORIGINATED BY S.M
DIST HWY 11 BOREHOLE TYPE CASING AND WASH BORING/NQ CORING COMPILED BY A.A
DATUM GEODETIC DATE 2014-9-4 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)		W _p	W	W _L		
								20 40 60 80 100						
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE					
201.8	GROUND SURFACE													
	100mm TOPSOIL		1	SS	5									
	SILTY CLAY , trace sand, trace gravel, firm, brown, wet		2	SS	5									0 0 27 73
200.4			3	SS	3									
1.4			4	TW	PH									0 0 63 37 0 0 23 77
	SILTY CLAY (Varved), containing 5mm to 20mm thick silt layers, stiff, grey, wet		5	SS	0*									0 0 27 73
			6	TW	PH									
			7	SS	0*									0 0 37 63
			8	SS	1									
			9	SS	0*									0 0 56 44
			10	SS	0*									
188.7			11	SS	100 / 75mm									
13.1	CLAYEY SILT , sandy, trace gravel, hard, grey, moist (GLACIAL TILL)		1	RUN	NQ									NQ Coring RUN# 1 TCR=100% SCR=100% RQD=86%
188.5	BEDROCK-LIMESTONE , (Dolomitic), slightly weathered (13.3m-14.9m) to moderately weathered (14.9m-16.3m) medium to thickly bedded, grey to whitish grey, medium to high strength, vuggy (frequent vugs at 15.2m-16.3m)		2	RUN	NQ									RUN# 2
13.3														

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH (m)	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100					w _p w w _L				
								SHEAR STRENGTH (kPa)					WATER CONTENT (%)				
	(continued)																
185.5	BEDROCK-LIMESTONE, (Dolomitic), slightly weathered (13.3m-14.9m) to moderately weathered (14.9m-16.3m) medium to thickly bedded, grey to whitish grey, medium to high strength, vuggy (frequent vugs at 15.2m-16.3m)		2	RUN	NQ		186									GR SA SI C TCR=100% SCR=92% RQD=37%	

*(ag) - above ground.

<u>Date</u>	<u>Water Depth (m)</u>	<u>Elevation (m)</u>
Sep 17, 2014	-0.1 (ag)*	n/a
Oct 28, 2014	-0.5 (ag)*	n/a
Nov 24, 2014	-0.6 (ag)*	n/a

RECORD OF BOREHOLE No 3

1 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404536.5 N:5269374.3 ORIGINATED BY S.M
DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS / CASING AND WASH BORING/NQ CORING COMPILED BY A.A
DATUM GEODETIC DATE 2014-8-27 - 2014-8-28 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100							
								SHEAR STRENGTH (kPa)							
								○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE							
PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _P															

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

2 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404536.5 N:5269374.3 ORIGINATED BY S.M
DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS / CASING AND WASH BORING/NQ CORING COMPILED BY A.A
DATUM GEODETIC DATE 2014-8-27 - 2014-8-28 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)							WATER CONTENT (%)			
								20 40 60 80 100							w _p w w _L			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
	(continued)						20	40	60	80	100	10	20	30		GR SA SI CL		
	SILTY CLAY (Varved), containing 10mm to 30mm thick silt layers, stiff, grey, wet		21	SS	0*					4.2					44	○	0 0 38 62	
											3.8							
											4.1					50	○	0 0 45 55
												×						
											5.1							
											4.4							
					23	SS	0*									44	○	August 27, 2014 August 28, 2014 0 0 43 57
											4.4							
											3.6							
					24	TW	PH											
											3.8							
											3.4							
			25	SS	0*									42	○	0 0 43 57		
									2.1									
									4.5									
			26	SS	1													
									2.9									
									3.4									
			27	SS	0*										○			
									4.6									
									3.2									
			28	SS	8													
187.2																		
26.5																		
186.5	CLAYEY SILT , trace to some sand, trace gravel, occasional cobbles, hard, grey, moist (GLACIAL TILL)		29	SS	106 / 225mm											NQ Coring		
27.2	BEDROCK-LIMESTONE , (Dolomitic), slightly weathered to 29.3m, moderately weathered below, medium to thickly bedded, grey to whitish grey, medium to high strength, vuggy (frequent vugs at 29.3m-30.3m)																	
			1	RUN	NQ											RUN #1 TCR=100% SCR=97% RQD=94%		
			2	RUN	NQ											RUN #2 TCR=100% SCR=100% RQD=61%		

Continued Next Page



+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

3 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404536.5 N:5269374.3 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS / CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-8-27 - 2014-8-28 CHECKED BY R.A

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE						
183.5 30.3	(continued)		2	RUN	NQ						

END OF BOREHOLE

Borehole filled with drill water upon completion of drilling.

*Sampler sinking under weight of hammer and/ or rods.

Consolidation test performed on TW22

RECORD OF BOREHOLE No 4

1 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404541 N:5269354.3 ORIGINATED BY S.M
DIST HWY 11 BOREHOLE TYPE CASING AND WASH BORING/NQ CORING COMPILED BY A.A
DATUM GEODETIC DATE 2014-8-26 - 2014-8-27 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100							PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
								SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE												
213.9	GROUND SURFACE																			
213.5	360mm ASPHALTIC CONCRETE																			
0.4	540mm FILL, SAND, some silt, some gravel, trace clay, very dense, brown, drv		1	SS	50 / 100mm		213													
213.0	FILL, silty clay, trace sand to sandy, trace gravel, trace organics below 6.9m, occasional cobbles, firm to very stiff, brown, moist to wet		2	SS	7		212													
0.9			3	SS	9		211								6 34 34 26					
			4	SS	13		210													
			5	SS	30		209													
			6	SS	8		208													
			7	SS	6		207													
			8	SS	3		206													
			9	SS	7		205													
206.4			10	SS	7		204													
7.5	SILTY CLAY, trace sand, trace organics, firm, brown to grey, wet		11	SS	4		203								0 2 21 77					
			12	SS	5		202													
							201								0 1 47 52					
203.8			13	SS	0*		200													
10.1	SILTY CLAY (Varved), containing 10mm to 20mm thick silt layers, stiff, grey, wet		14	TW	PH		199													
			15	SS	0															

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



August 26, 2014
August 27, 2014

RECORD OF BOREHOLE No 4

2 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404541 N:5269354.3 ORIGINATED BY S.M
DIST HWY 11 BOREHOLE TYPE CASING AND WASH BORING/NQ CORING COMPILED BY A.A
DATUM GEODETIC DATE 2014-8-26 - 2014-8-27 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)							WATER CONTENT (%)		
								20 40 60 80 100							W _p W W _L		
	(continued)																
	SILTY CLAY (Varved), containing 10mm to 20mm thick silt layers, stiff, grey, wet		16	TW	PH												
			17	SS	0*												
			18	SS	1												
			19	SS	0*												
			20	SS	0*												
	BEDROCK-LIMESTONE, (Dolomitic), slightly weathered, thinly to thickly bedded, grey to whitish grey, high strength, vuggy		21	SS	1												
			22	SS	0*												
			23	SS	0*												
187.1 26.8																	
			1	RUN	NQ												
			2	RUN	NQ												
183.9																	

Continued Next Page

END OF BOREHOLE

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

library: library - terraprobe gint.gdb report: mto-terraprobe soil file: 11-14-4066 (47-273c) calanity creek.gpj

RECORD OF BOREHOLE No 4

3 of 3

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404541 N:5269354.3 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-8-26 - 2014-8-27 CHECKED BY R.A

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT NUMBER	TYPE			SHEAR STRENGTH (kPa)		W _p	W	W _L	γ	
						20 40 60 80 100	20 40 60 80 100					
						○ UNCONFINED	+ FIELD VANE	WATER CONTENT (%)				
						● QUICK TRIAXIAL	× LAB VANE					
						20 40 60 80 100	20 40 60 80 100	10	20	30	kN/m ³	GR SA SI CL

(continued)

30.0

Borehole filled with drill water
upon completion of drilling.

*Sampler sinking under weight of
hammer and/ or rods

Insufficient sample available for
Atterberg limits test at SS12

RECORD OF BOREHOLE No 5

1 of 2

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404496.3 N:5269354.8 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS/CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-8-29 - 2014-9-3 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100									
								SHEAR STRENGTH (kPa)									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
								PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT									
								W _p W W _L									
								WATER CONTENT (%)									
203.5	GROUND SURFACE																
203.4 0.2	150mm TOPSOIL		1	SS	7		203										
	FILL, sand and silt, some clay, trace gravel, very loose to compact, brown, wet		2	SS	12		202							4 45 37 14			
			3	SS	2		201										
201.4 2.1	SILTY CLAY, trace sand, trace gravel, soft to stiff, brown, wet		4	SS	2		200										
	...		5	SS	4		199										
	containing organics		6	SS	13		198										
			7	TW	PH		197							Aug. 29, 2014 Sept. 2, 2014 commence casing and washing			
197.9 5.6	SILTY CLAY (Varved), containing 10mm to 20mm thick silt layers, firm to stiff, grey, wet		8	SS	0*		196							0 0 29 71			
			9	TW	PH		195										
			10	SS	0*		194										
			11	SS	0*		193							0 0 43 57			
			12	SS	0*		192										
							191							Sept. 2, 2014 Sept. 3, 2014			
							190							0 0 51 49			
							189										

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

2 of 2

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404496.3 N:5269354.8 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS/CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-8-29 - 2014-9-3 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)							WATER CONTENT (%)						
	(continued)						20	40	60	80	100	w _p	w	w _L	GR	SA	SI	CL			
	SILTY CLAY (Varved), containing 10mm to 20mm thick silt layers, firm to stiff, grey, wet		13	SS	0*																
186.8																					
16.7	CLAYEY SILT, sandy, trace gravel, firm to hard, grey, moist (GLACIAL TILL)		14	SS	5													9	29	47	15
186.0			15	SS	100 / 50mm																
17.5	BEDROCK-LIMESTONE, (Dolomitic), slightly weathered, thinly to medium bedded, grey to whitish grey, high strength, vuggy		1	RUN	NQ																
			2	RUN	NQ																
183.0																					
										</											

END OF BOREHOLE

Borehole filled with drill water upon
completion of drilling.

*Sampler sinking under weight of
hammer and/ or rods.

Insufficient sample available for
Atterberg limits test at SS6

RECORD OF BOREHOLE No 6

1 of 2

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404454.7 N:5269290.3 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS/CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-9-3 CHECKED BY R.A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)										
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100																
								SHEAR STRENGTH (kPa)																
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	W _p — W — W _L												
								20 40 60 80 100					WATER CONTENT (%)											
197.7	GROUND SURFACE																							
197.6 0.2	150mm TOPSOIL SILTY CLAY , trace sand, trace organics, soft to firm, brown, wet		1	SS	3								○											
			2	SS	4		197																	
			3	SS	2		196						41	commence casing and washboring 0 1 43 56										
195.6 2.1	SILTY CLAY (Varved), containing 5mm to 20mm thick silt layers, firm to stiff, grey, wet						195	3.7																
			4	TW	PH		194	3.7																
							193	8.0					43	0 0 53 47										
			5	SS	0*		192	5.1																
							191	7.4																
			6	TW	PH		190	3.6					47	0 0 40 60										
							189	5.6																
							188	5.8																
			7	SS	0*		187	7.5						0 1 69 30										
							186	5.0					○											
			8	SS	0*		185	7.3						NQ Coring										
							184	5.6						RUN #1 TCR=100% SCR=97% RQD=88%										
			9	SS	0*		183	5.2						RUN #2 TCR=100% SCR=100% RQD=95%										
185.6 12.1	BEDROCK-LIMESTONE , (Dolomitic), slightly weathered, medium to thickly bedded, grey to whitish grey, high strength, vuggy		10	SS	100 / 50mm																			
			1	RUN	NQ																			
			2	RUN	NQ																			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


library: library - terraprobe gint - md.gib report: mto-terraprobe soil file: 11-14-4086 (47-273c) calanity creek.gpj

RECORD OF BOREHOLE No 6

2 of 2

METRIC

G.W.P. 5159-12-00 LOCATION Coords: E:404454.7 N:5269290.3 ORIGINATED BY S.M
 DIST HWY 11 BOREHOLE TYPE HOLLOW STEM AUGERS/CASING AND WASH BORING/NQ CORING COMPILED BY A.A
 DATUM GEODETIC DATE 2014-9-3 CHECKED BY R.A

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE								
182.5 15.2	(continued)		2	RUN	NQ								

END OF BOREHOLE

Borehole filled with drill water upon completion of drilling.

*Sampler sinking under weight of hammer and/ or rods.

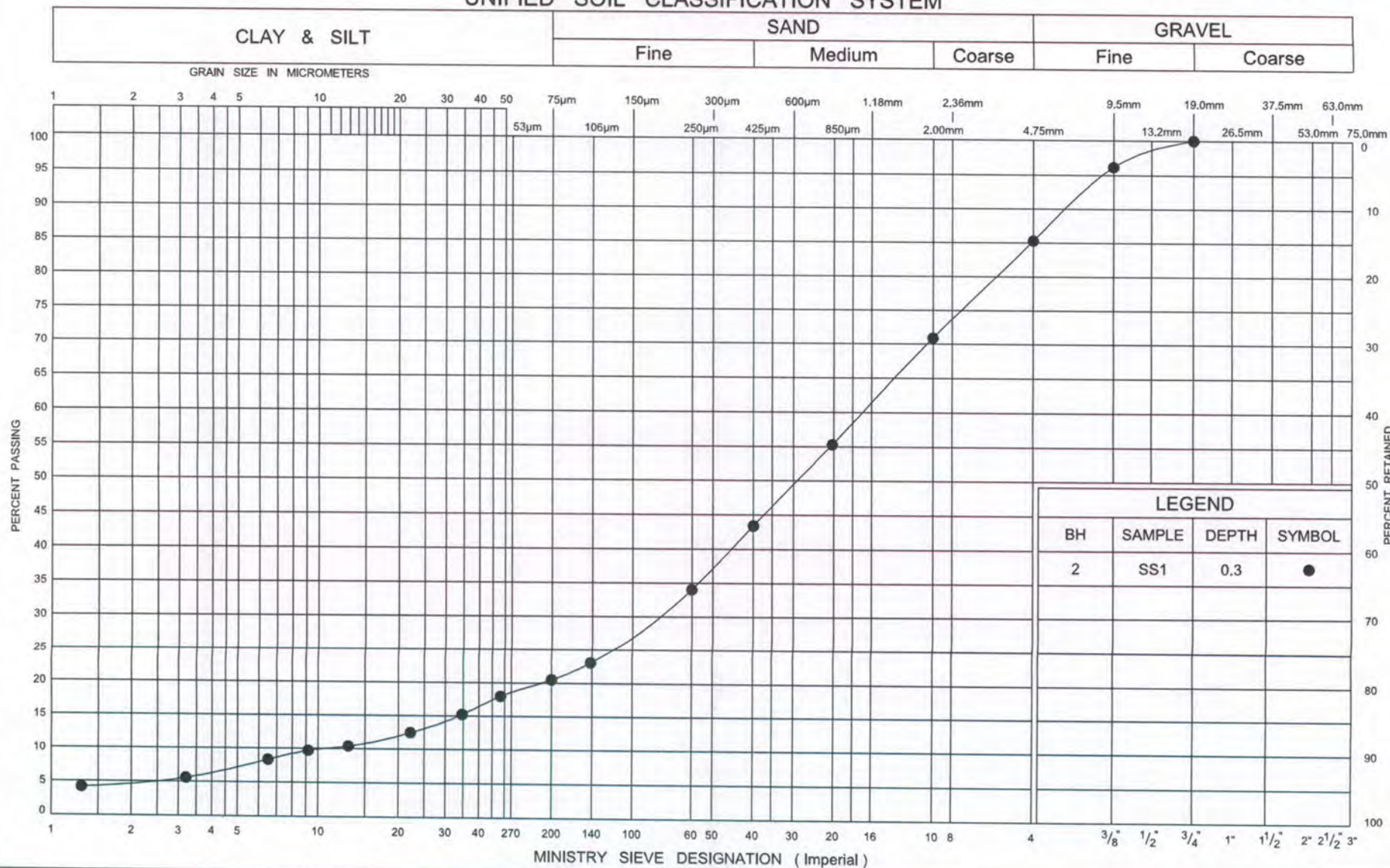
Piezometer installation consists of a 25mm diameter schedule 40PVC pipe with a 3.0m slotted screen.

*(ag) - above ground.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Sep 17, 2014	-0.3 (ag)*	n/a
Oct 28, 2014	-0.4 (ag)*	n/a
Nov 24, 2014	-0.4 (ag)*	n/a

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION FILL-SAND

FIG No B1-1

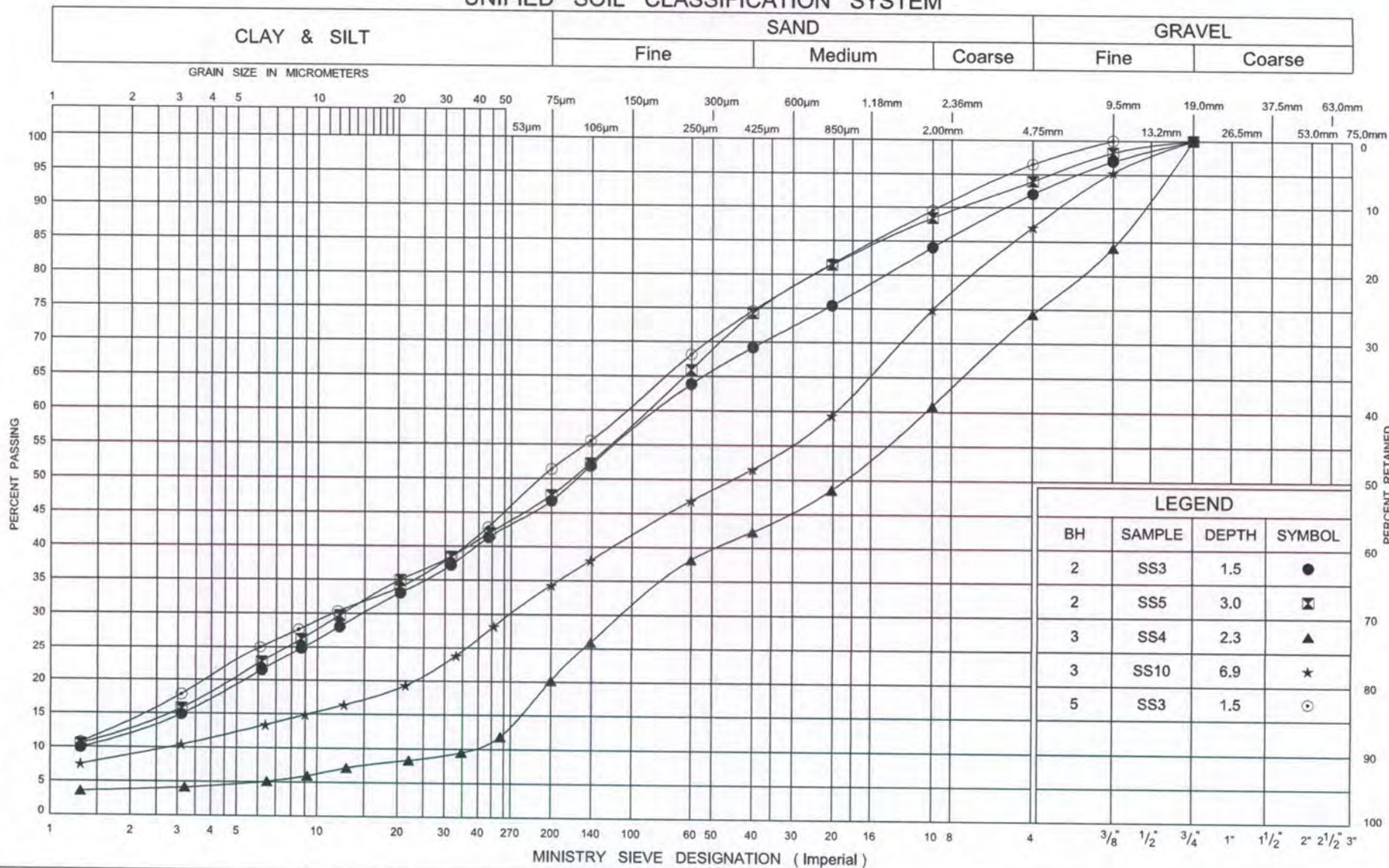
G W P 5159-12-00

Calamity Creek Culvert (47-273C)



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Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



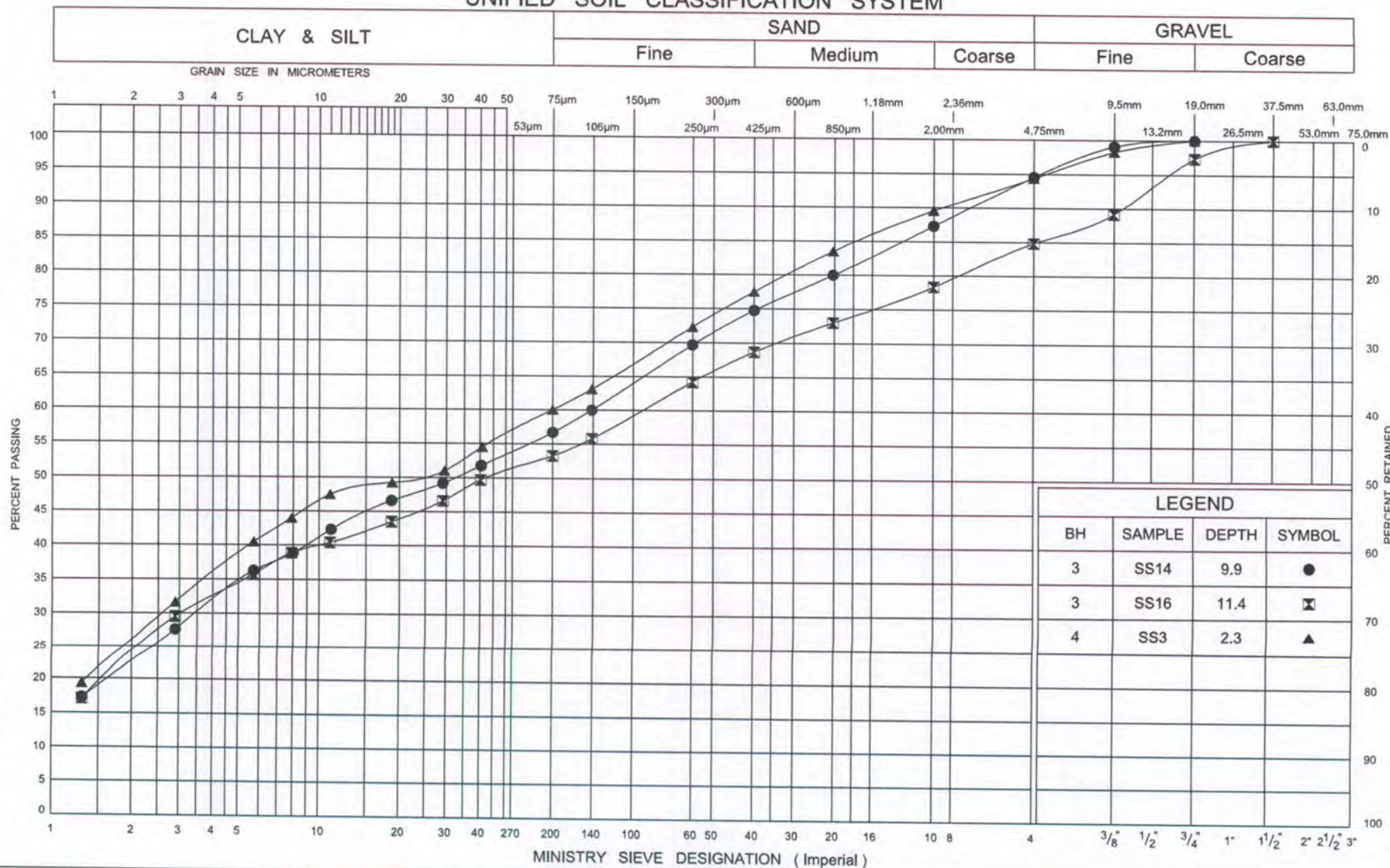
GRAIN SIZE DISTRIBUTION FILL-GRAVELLY SAND TO SAND AND SILT

FIG No B1-2

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION FILL-SILTY CLAY

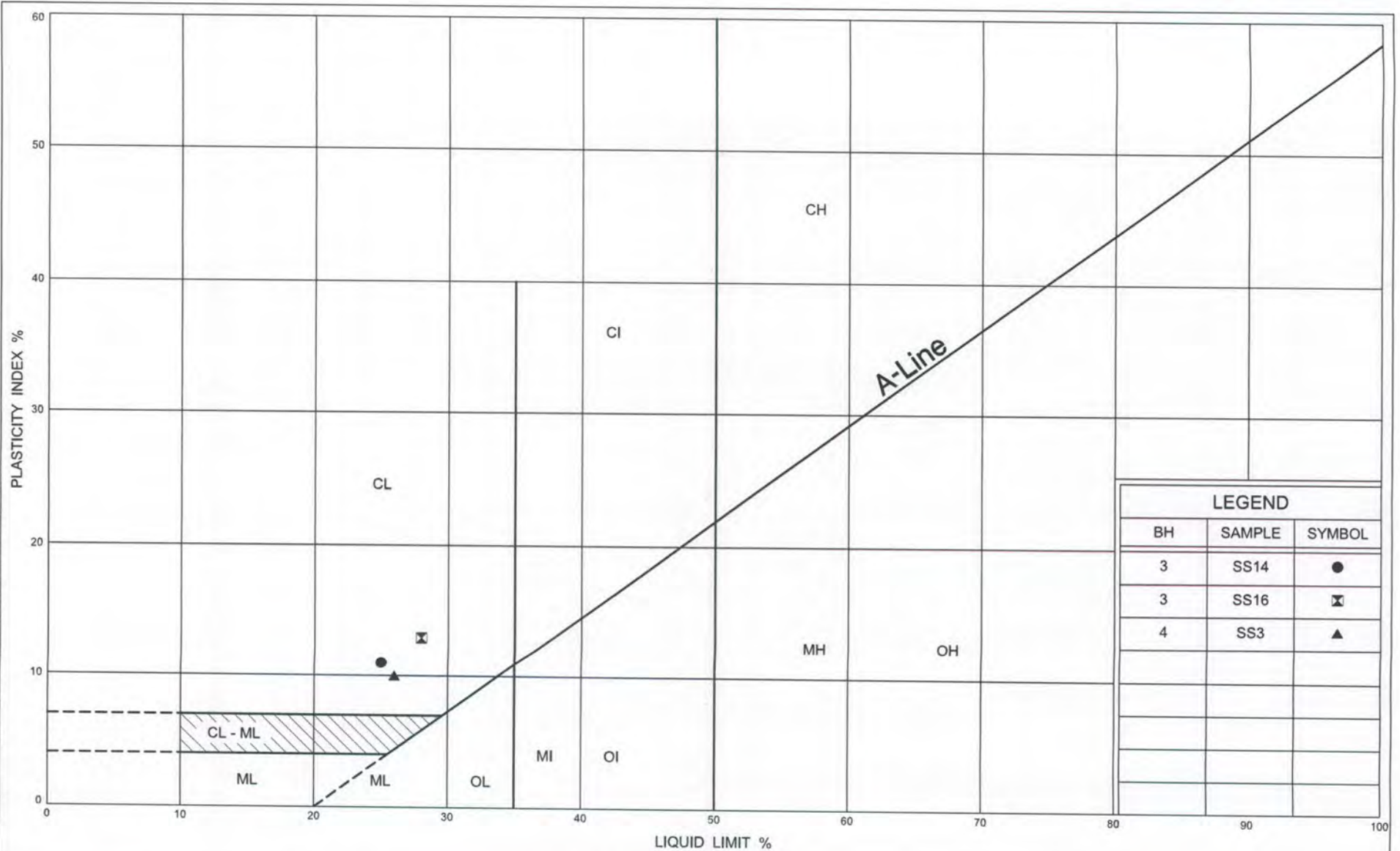
FIG No B1-3

G W P 5159-12-00

Calamity Creek Culvert (47-273C)



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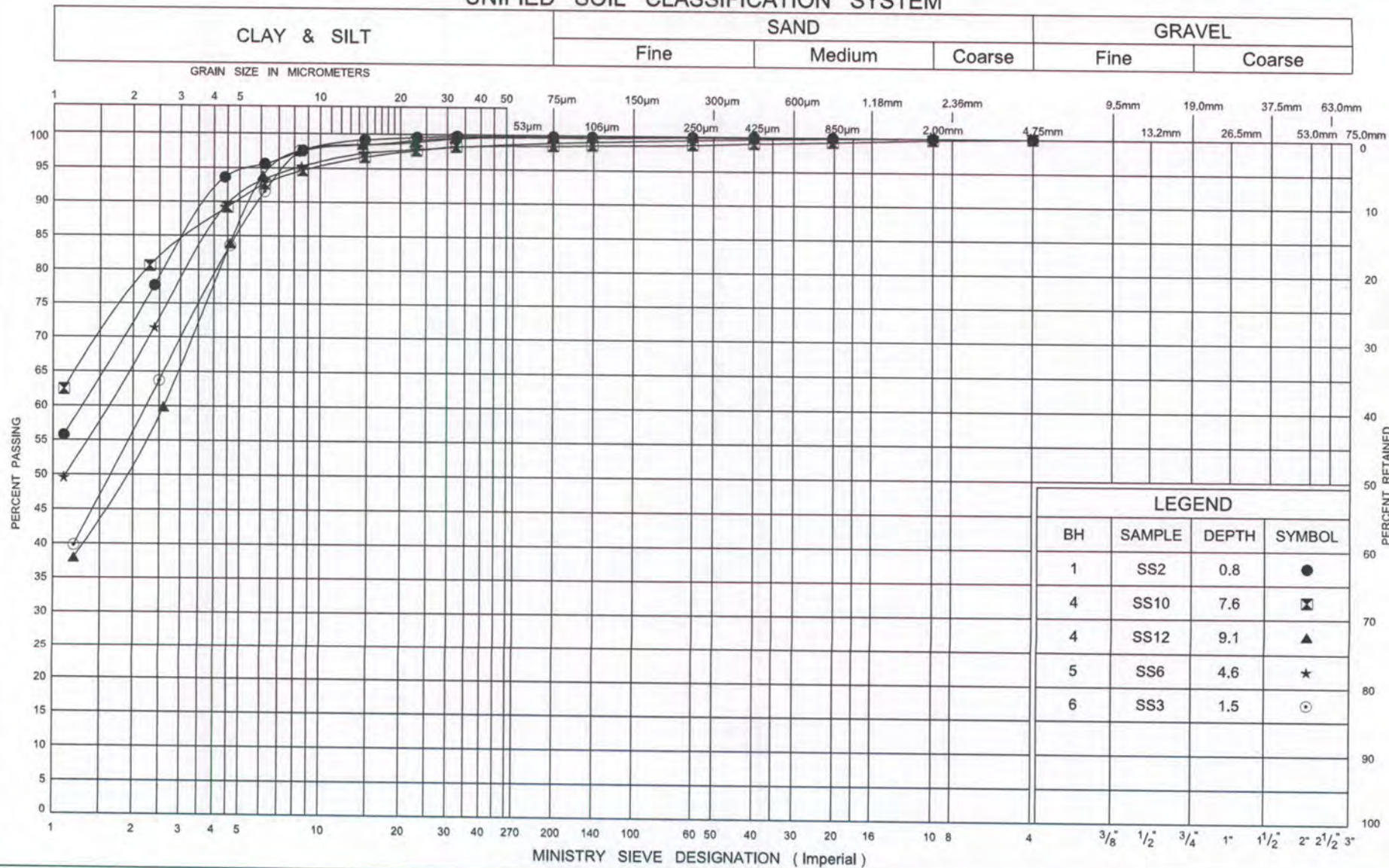
PLASTICITY CHART FILL-SILTY CLAY

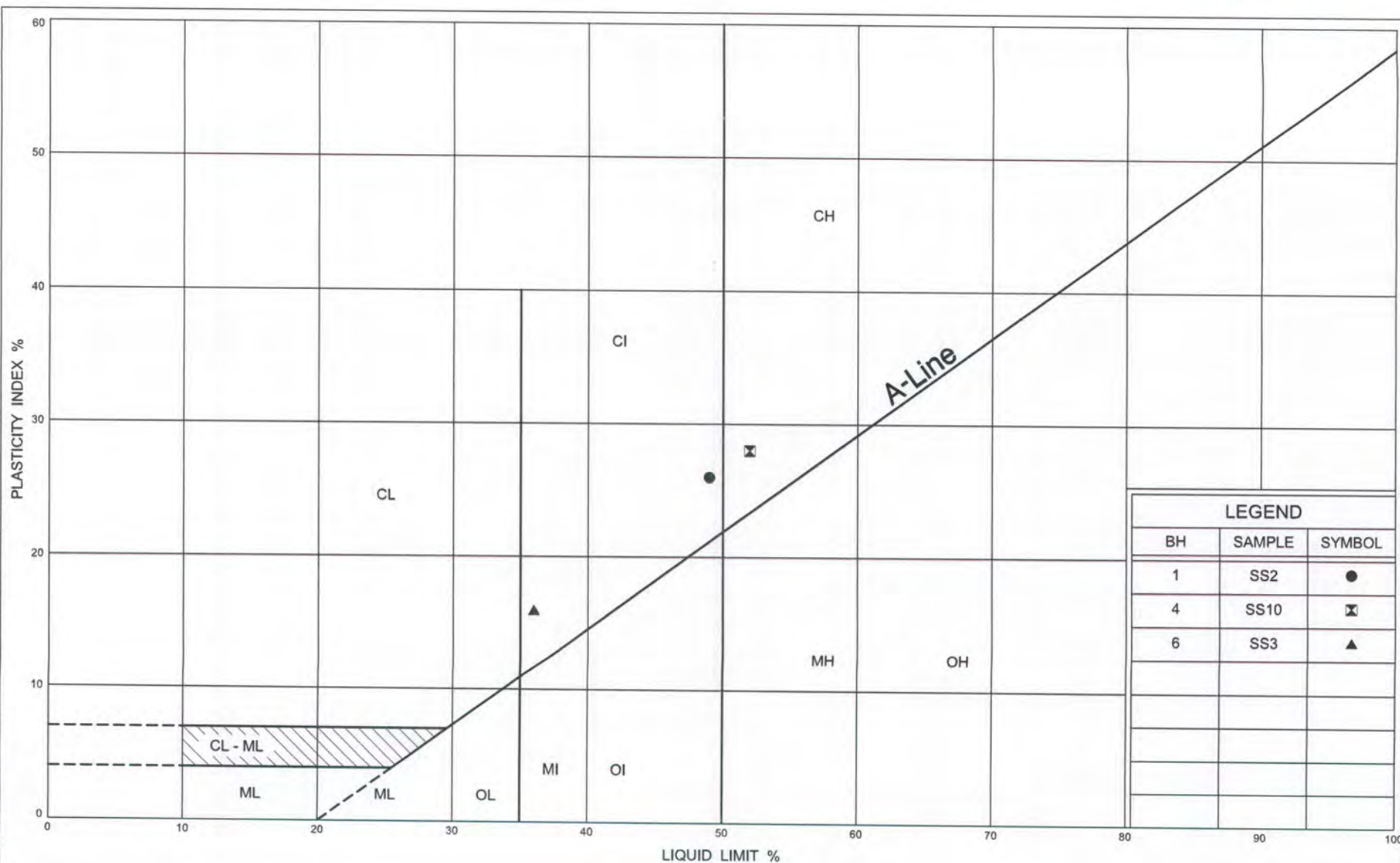
FIG No B1-4

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

UNIFIED SOIL CLASSIFICATION SYSTEM





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Transportation

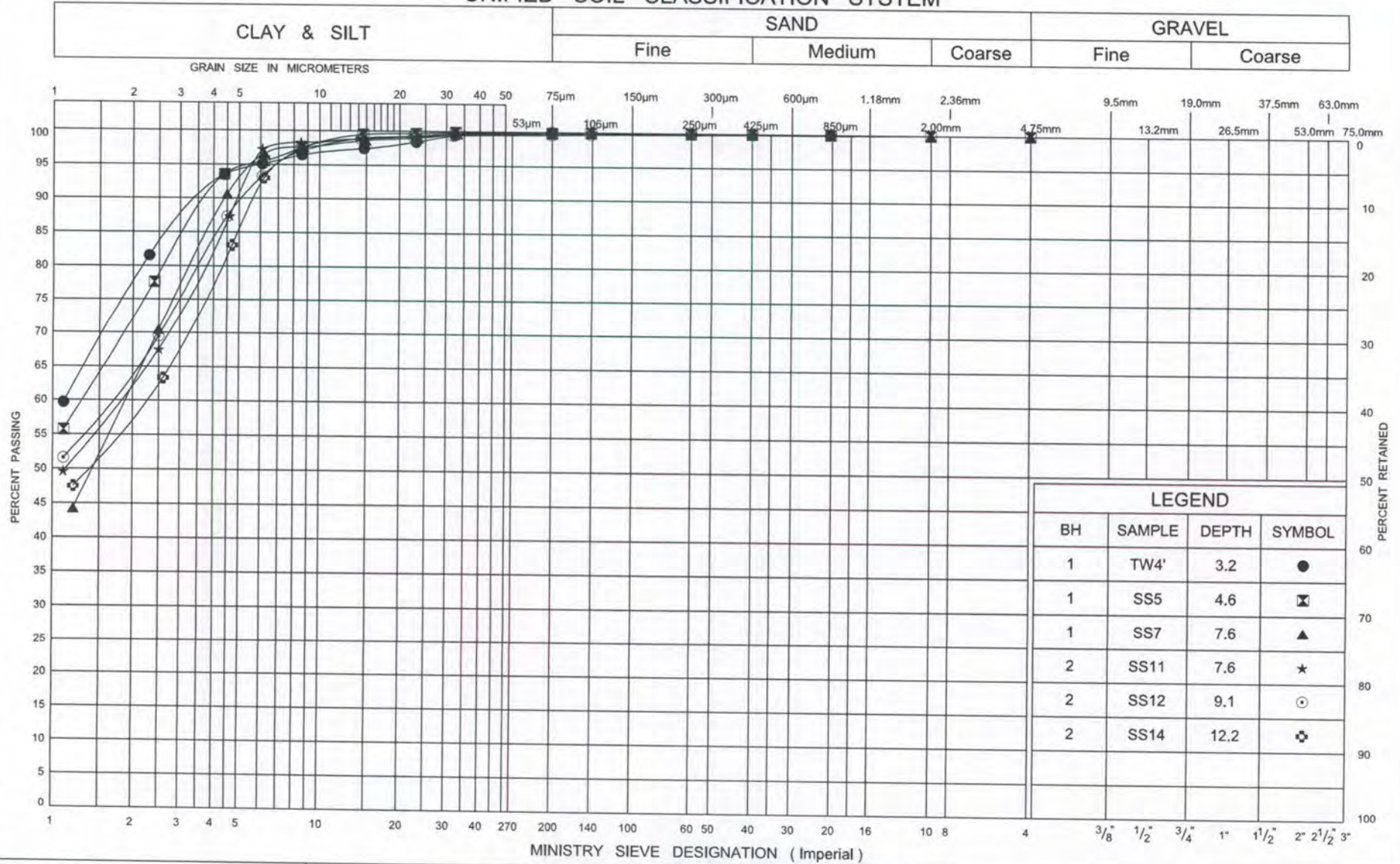
PLASTICITY CHART SILTY CLAY

FIG No B1-6

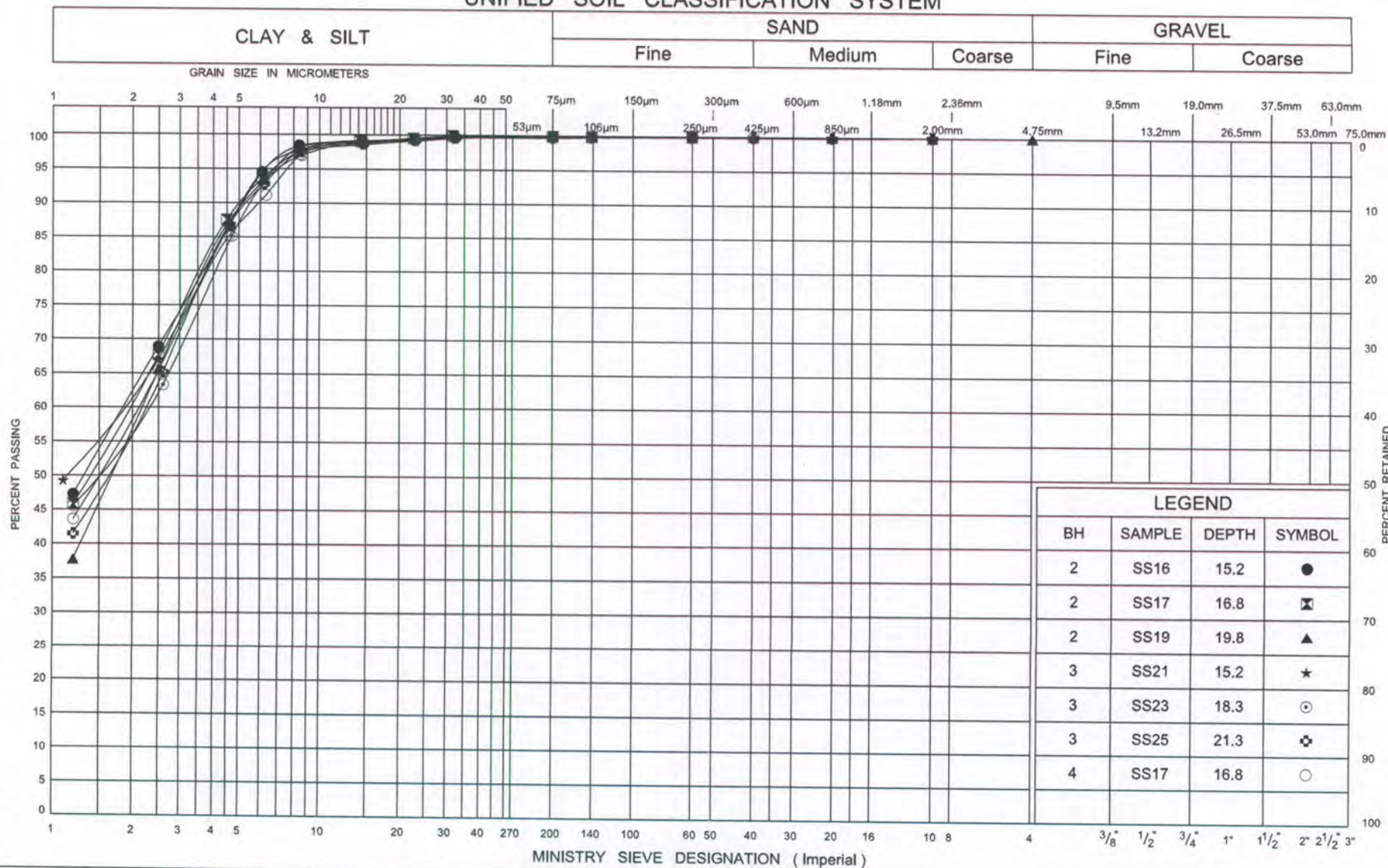
G W P 5159-12-00

Calamity Creek Culvert (47-273C)

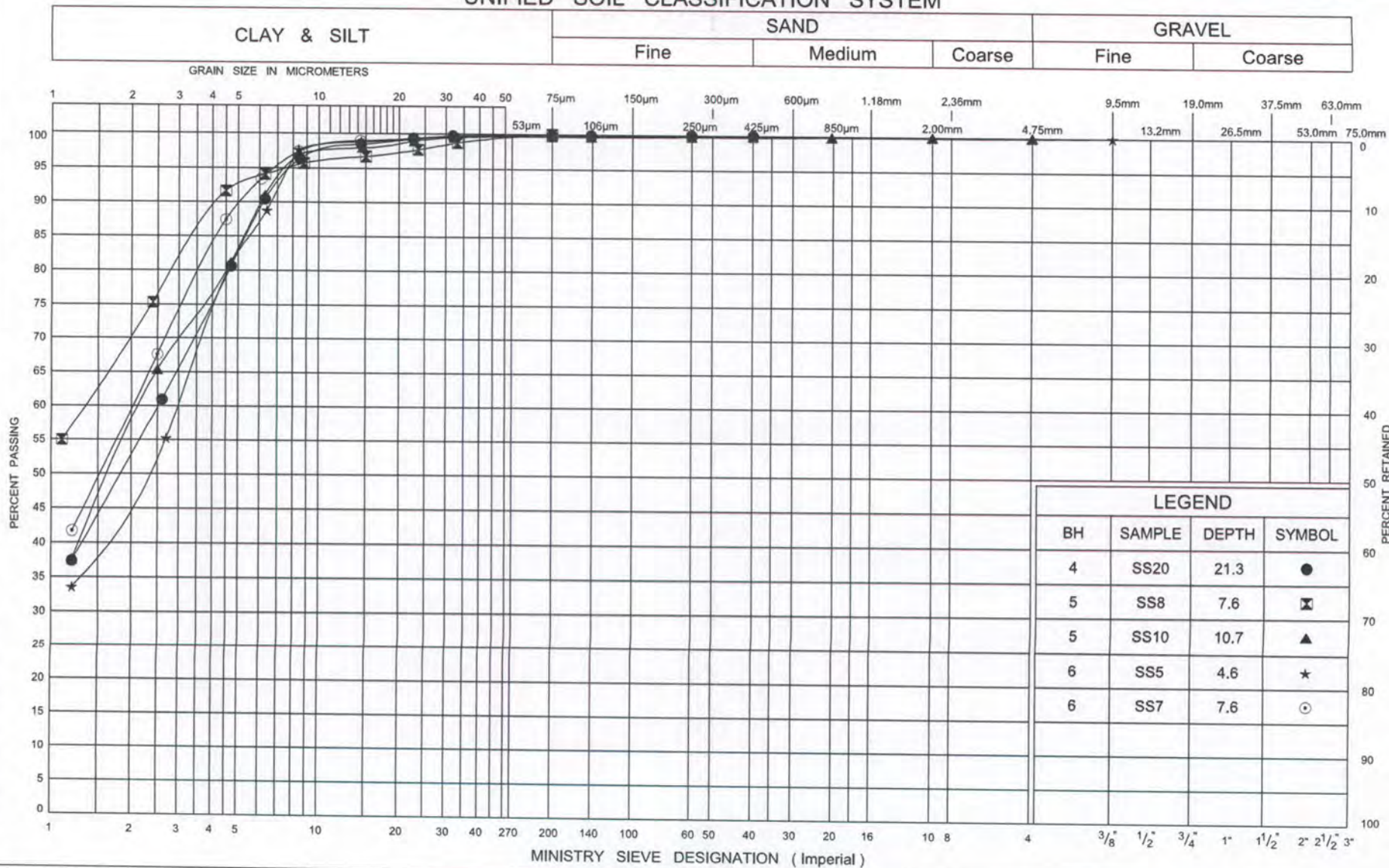
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

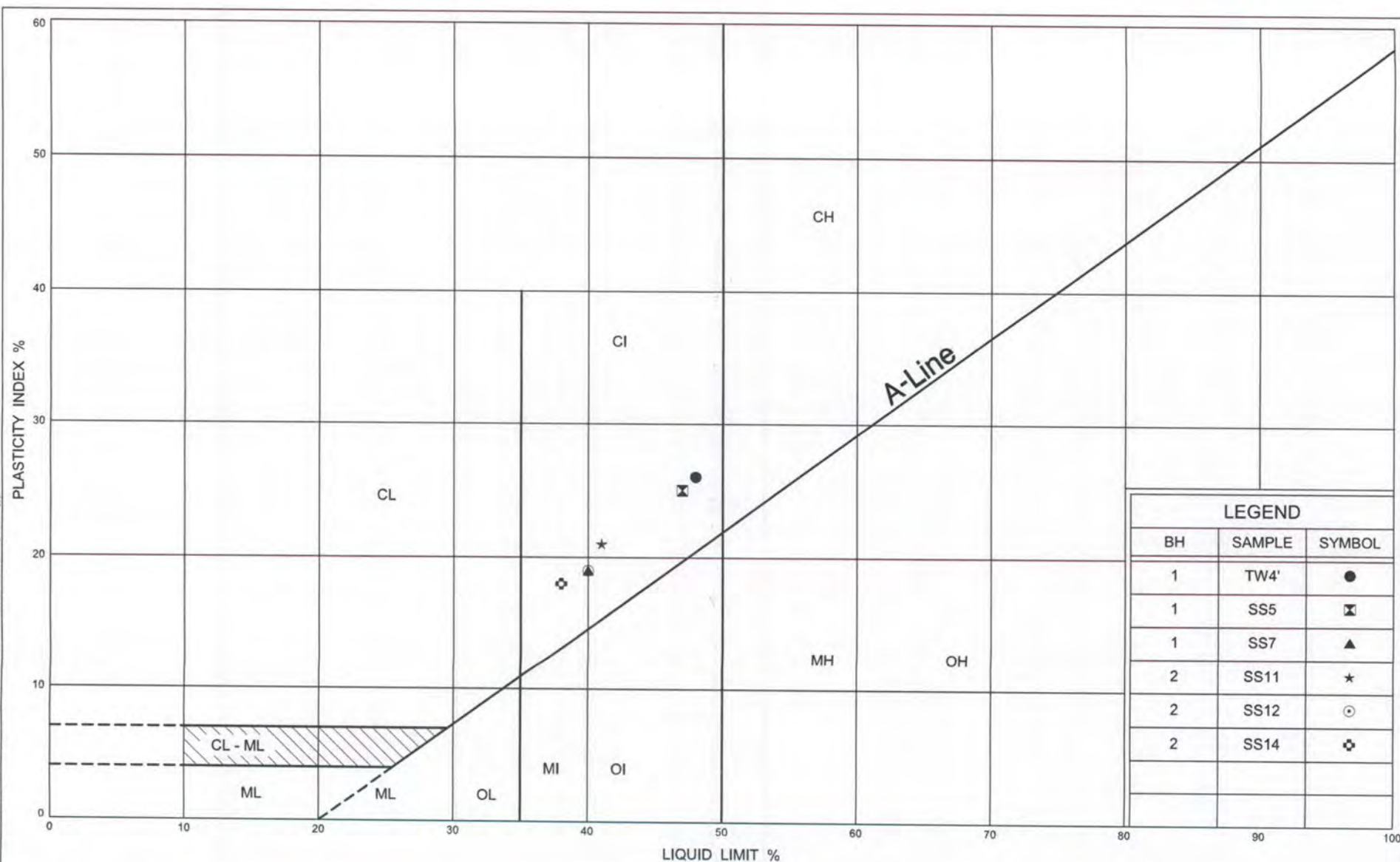
GRAIN SIZE DISTRIBUTION SILTY CLAY (VARVED)

FIG No B1-11

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

library: library - terraprobe.gint - md.gib report: mto-terra-plasticity-chart file: 11-14-4066 (47-273c) calamity creek.gpi



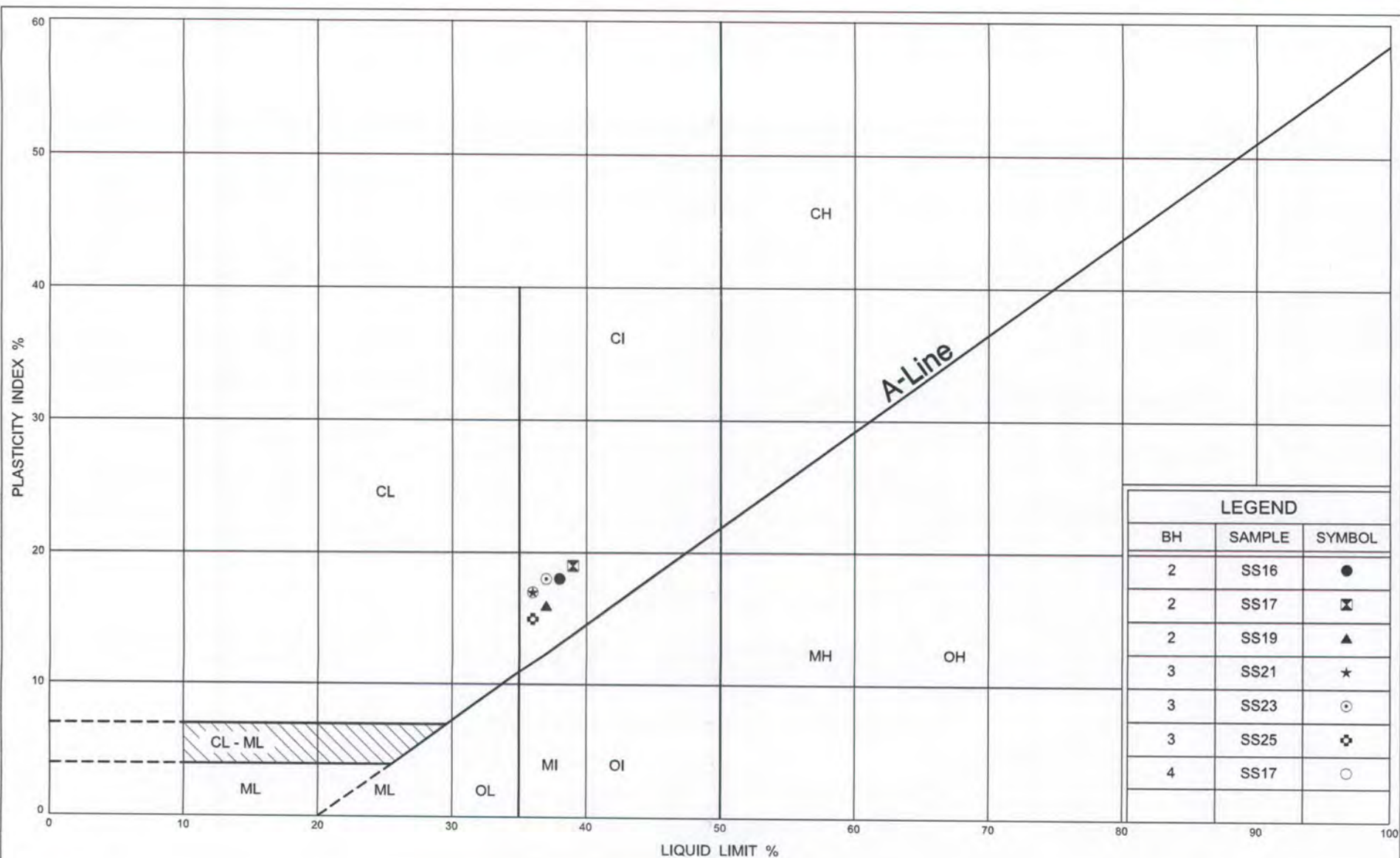
Ministry of
Transportation

PLASTICITY CHART
SILTY CLAY (VARVED)

FIG No B1-12

G W P 5159-12-00

Calamity Creek Culvert (47-273C)



Ministry of
Transportation

PLASTICITY CHART

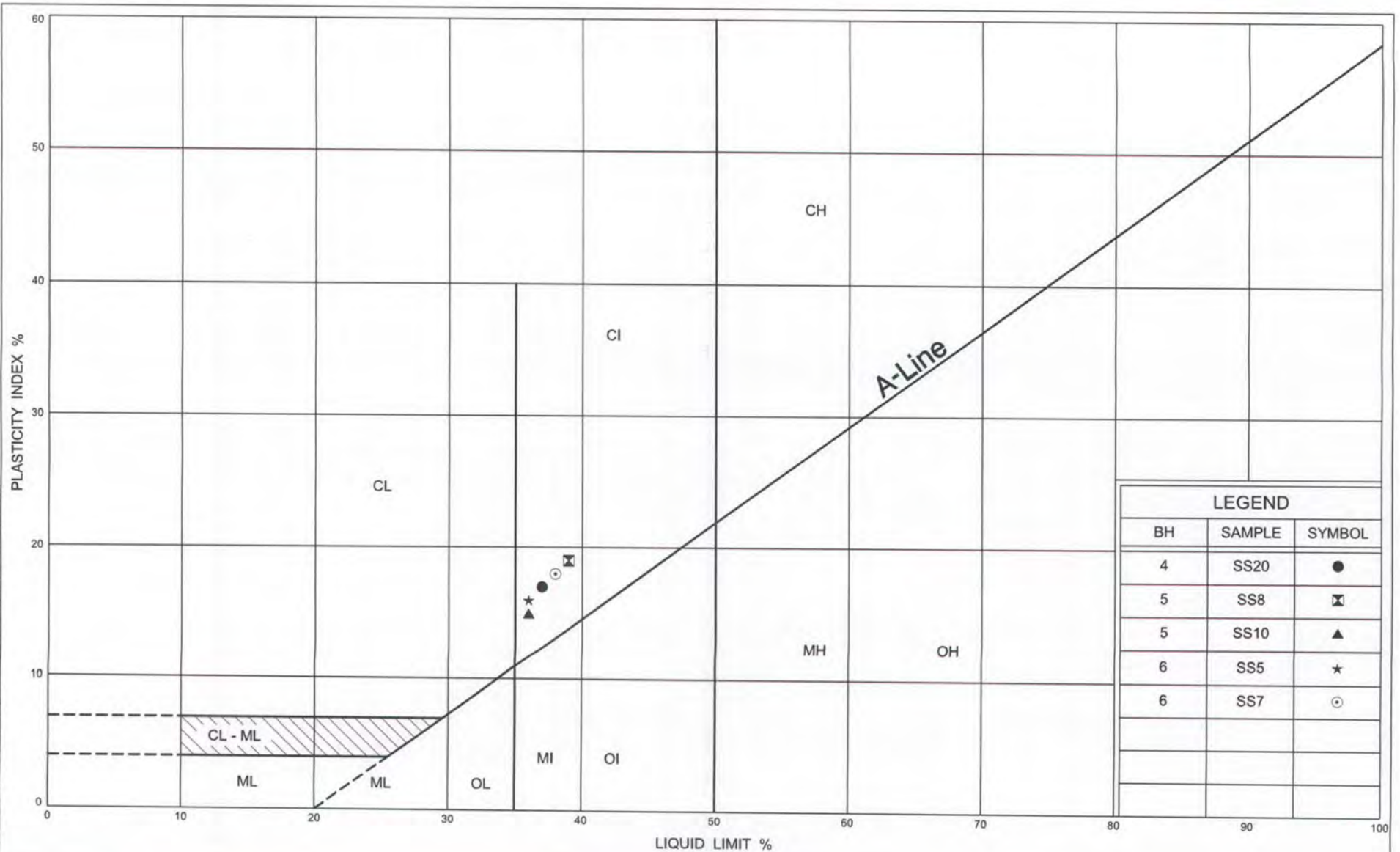
SILTY CLAY (VARVED)

FIG No B1-13

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

library: library - terraprobe gis - md.gis report: mto-terra plasticity chart file: 11-14-066 (47-273c) calamity creek.gis



Ministry of
Transportation

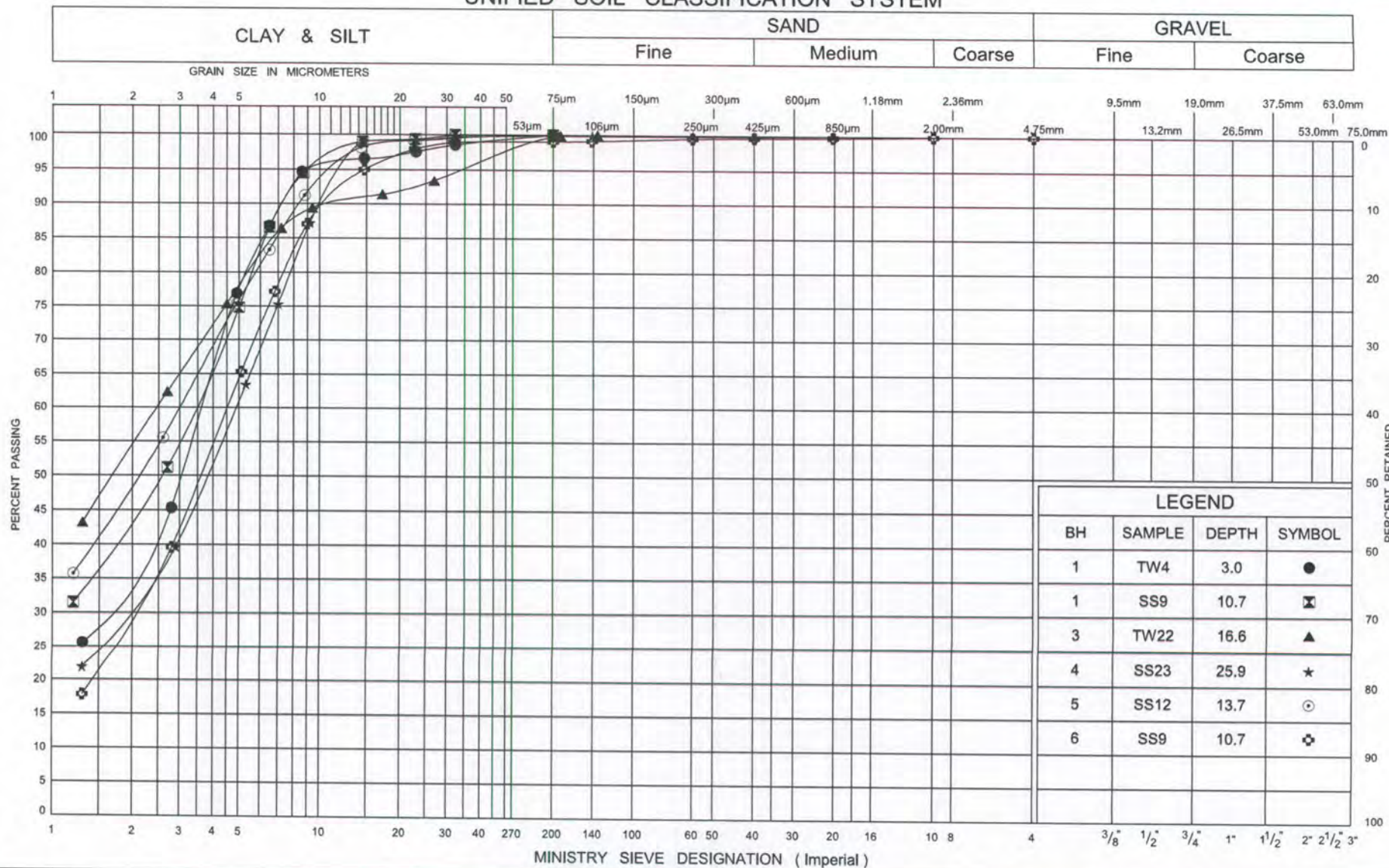
PLASTICITY CHART SILTY CLAY (VARVED)

FIG No B1-14

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

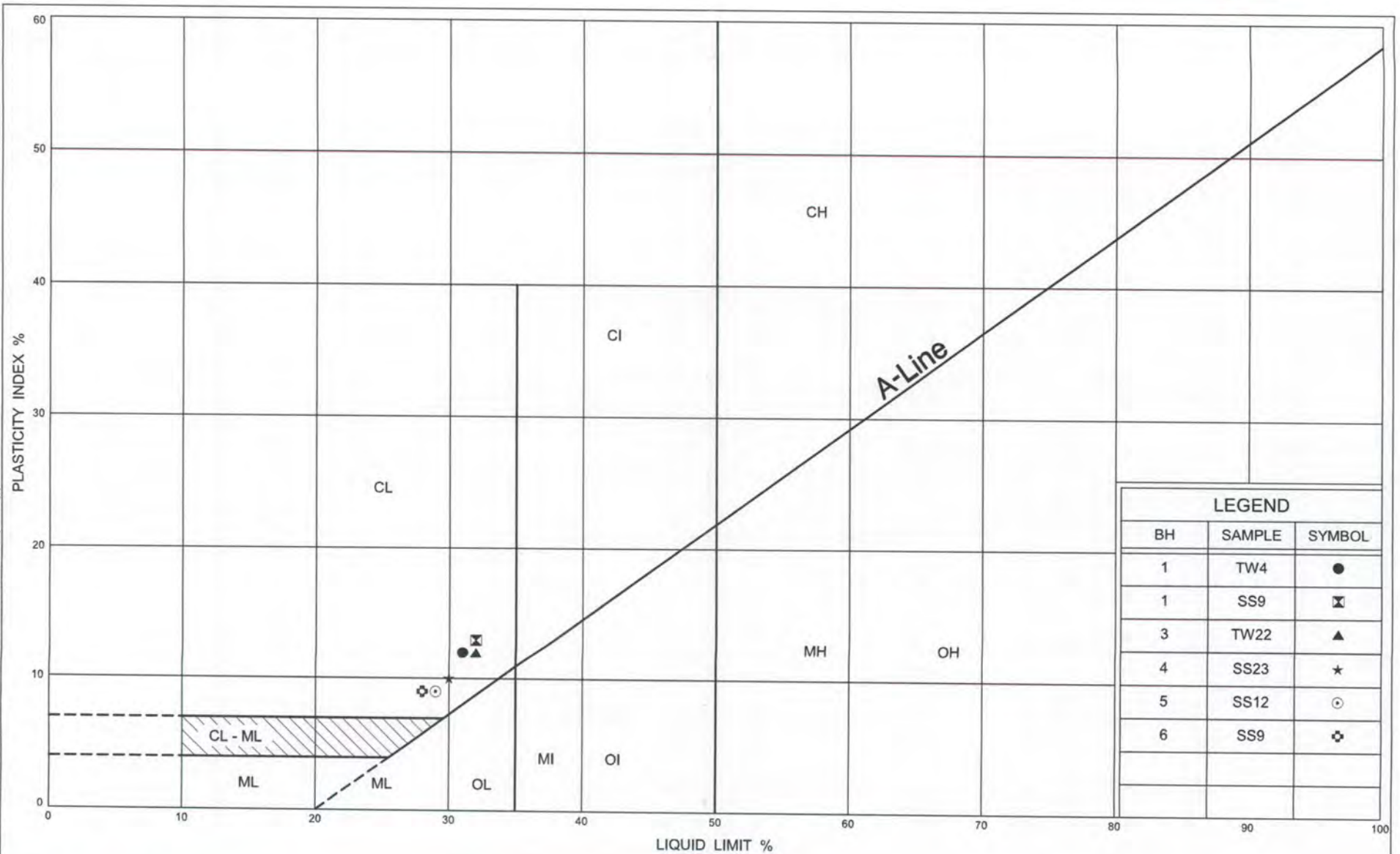
GRAIN SIZE DISTRIBUTION

SILTY CLAY (VARVED)

FIG No B1-15

G W P 5159-12-00

Calamity Creek Culvert (47-273C)



Ministry of
Transportation

PLASTICITY CHART SILTY CLAY (VARVED)


FIG No B1-16

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

CONSOLIDATION TEST SUMMARY

FIGURE B1-18

SAMPLE IDENTIFICATION							
Project Number	1414696 (2000)			Sample Number	TW22		
Borehole Number	3			Sample Depth, m	16.76-17.22		
TEST CONDITIONS							
Test Type	Laboratory Standard			Load Duration, hr	24		
Oedometer Number	9						
Date Started	10/01/2014						
Date Completed	10/16/2014						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.90			Unit Weight, kN/m ³	18.17		
Sample Diameter, cm	6.34			Dry Unit Weight, kN/m ³	13.23		
Area, cm ²	31.55			Specific Gravity, measured	2.72		
Volume, cm ³	60.04			Solids Height, cm	0.944		
Water Content, %	37.36			Volume of Solids, cm ³	29.77		
Wet Mass, g	111.22			Volume of Voids, cm ³	30.27		
Dry Mass, g	80.97			Degree of Saturation, %	99.9		
TEST COMPUTATIONS							
Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv, cm ² /s	mv m ² /kN	k cm/s
0.00	1.903	1.017	1.903				
6.51	1.896	1.010	1.900				
11.16	1.892	1.005	1.894	191	3.98E-03	5.20E-04	2.03E-07
21.00	1.888	1.001	1.890	427	1.77E-03	1.82E-04	3.16E-08
40.50	1.882	0.995	1.885	501	1.50E-03	1.64E-04	2.42E-08
79.35	1.870	0.981	1.876	360	2.07E-03	1.72E-04	3.49E-08
156.84	1.833	0.943	1.851	589	1.23E-03	2.47E-04	2.98E-08
311.96	1.767	0.873	1.800	667	1.03E-03	2.24E-04	2.26E-08
622.51	1.675	0.775	1.721	759	8.27E-04	1.56E-04	1.26E-08
1242.71	1.604	0.700	1.639	190	3.00E-03	6.02E-05	1.77E-08
2482.05	1.540	0.632	1.572	147	3.56E-03	2.72E-05	9.49E-09
1242.71	1.554	0.646	1.547				
311.96	1.585	0.680	1.569				
79.35	1.618	0.714	1.601				
21.00	1.650	0.749	1.634				
6.51	1.667	0.767	1.659				
<p>Note: Consolidation loading and unloading schedule assigned by the client. k calculated using cv based on t₉₀ values.</p>							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.67			Unit Weight, kN/m ³	19.36		
Sample Diameter, cm	6.34			Dry Unit Weight, kN/m ³	15.10		
Area, cm ²	31.55			Specific Gravity, measured	2.72		
Volume, cm ³	52.60			Solids Height, cm	0.944		
Water Content, %	28.25			Volume of Solids, cm ³	29.77		
Wet Mass, g	103.84			Volume of Voids, cm ³	22.83		
Dry Mass, g	80.97						
Prepared By: RD				Golder Associates		Checked By: 	

Note: One dimensional consolidation test was performed by Golder Associates Ltd.

Project No. : 11-14-4066
Date : January 2015



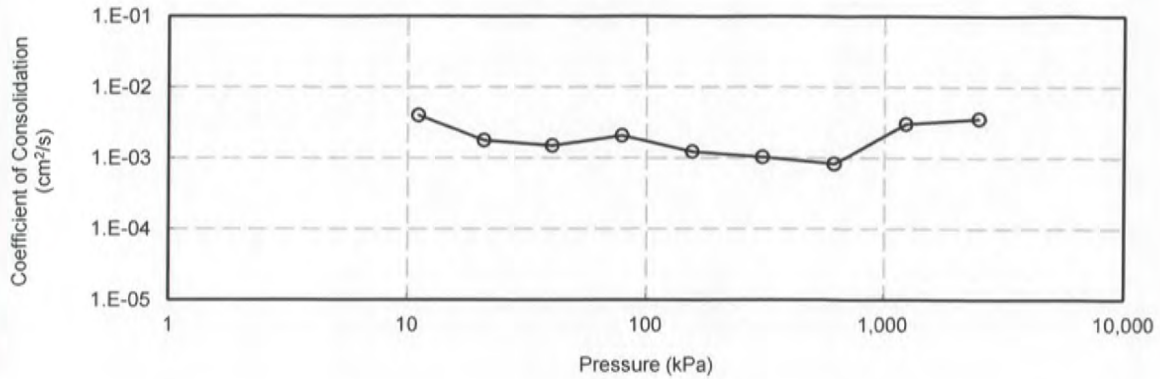
CONSOLIDATION TEST

FIGURE B1-19

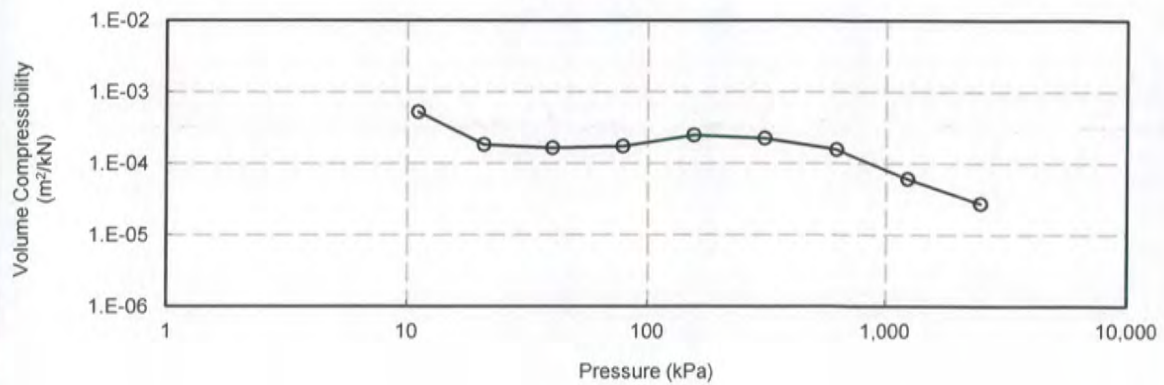
CALAMITY CREEK CULVERT(Site 47-273C)

BH 3, TW 22

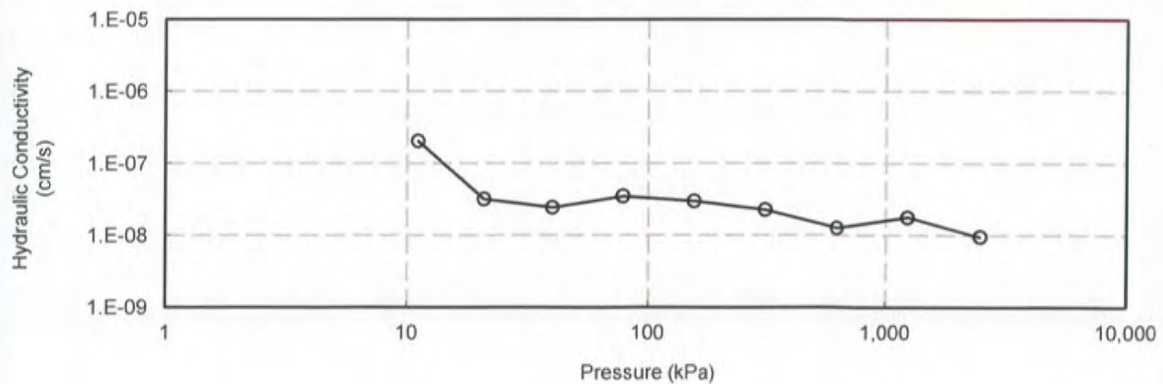
Cv vs Pressure



mv vs Pressure



k vs Pressure



Z:\11-Project Files\11-Geo\2014\11-14-4066 New Likard Area\11- Calamity Creek Culvert Hwy 11 (47-273C)\IG. Eng Analysis\Spread Sheets\Consolidation Results (Golder).xls

Project No. : 11-14-4066
Date : December 2014



Terraprobe Inc.

Prepared By : SD
Checked By : RA

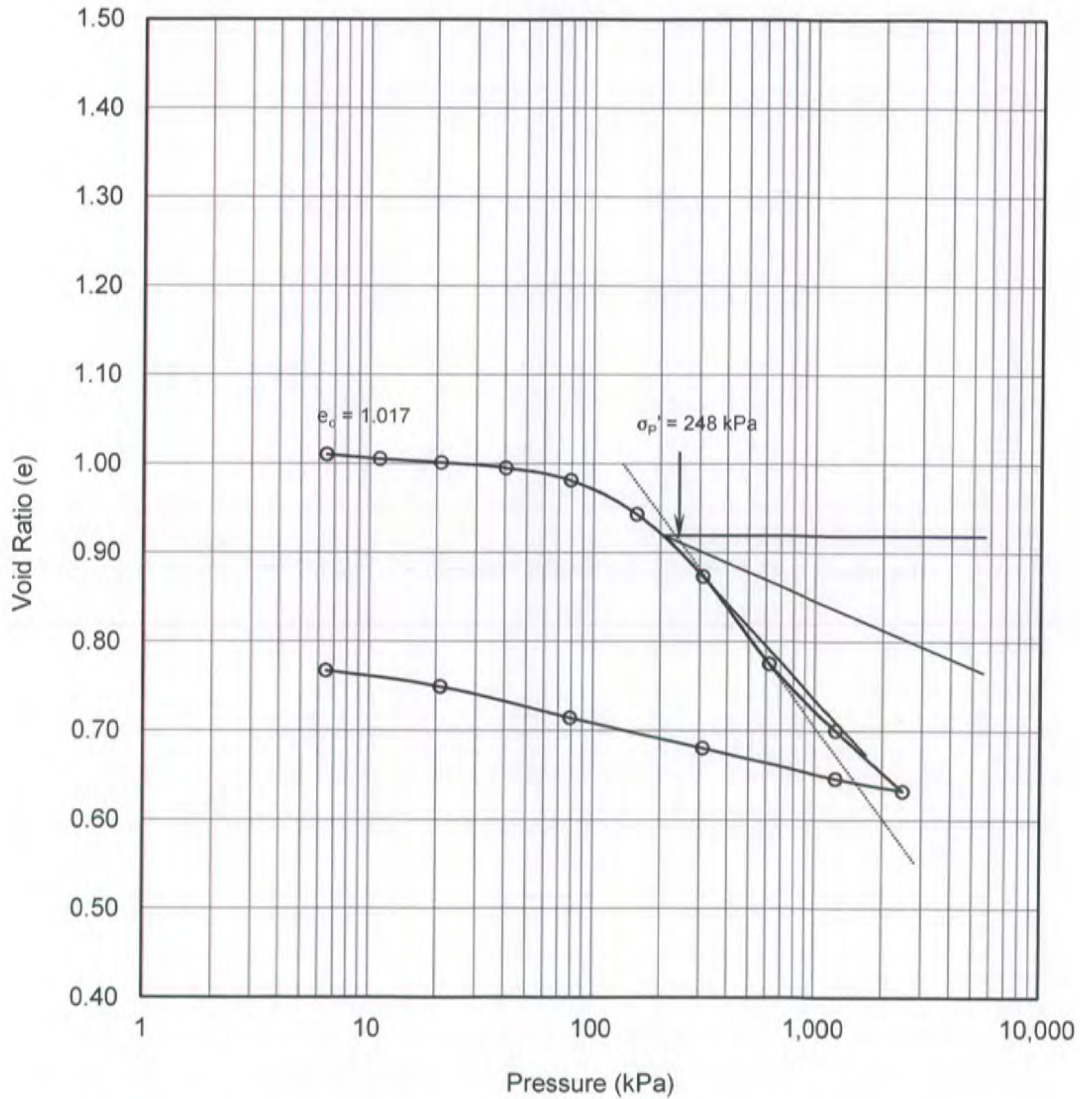
CONSOLIDATION TEST

FIGURE B1-20

CALAMITY CREEK CULVERT (Site 47-273C)

BH 3, TW 22

Void Ratio vs Pressure



Soil Type : SILTY CLAY to CLAY

$e_o =$	1.02	$\omega_L =$	32%	$\sigma_{v0}' =$	265.2 kPa
$\omega =$	50%	$\omega_p =$	20%	$\sigma_p' =$	248.0 kPa
$\gamma =$	18.2 kN/m ³	PI =	12%		
Gs =	2.72				

Project No. : 11-14-4066
Date : December 2014



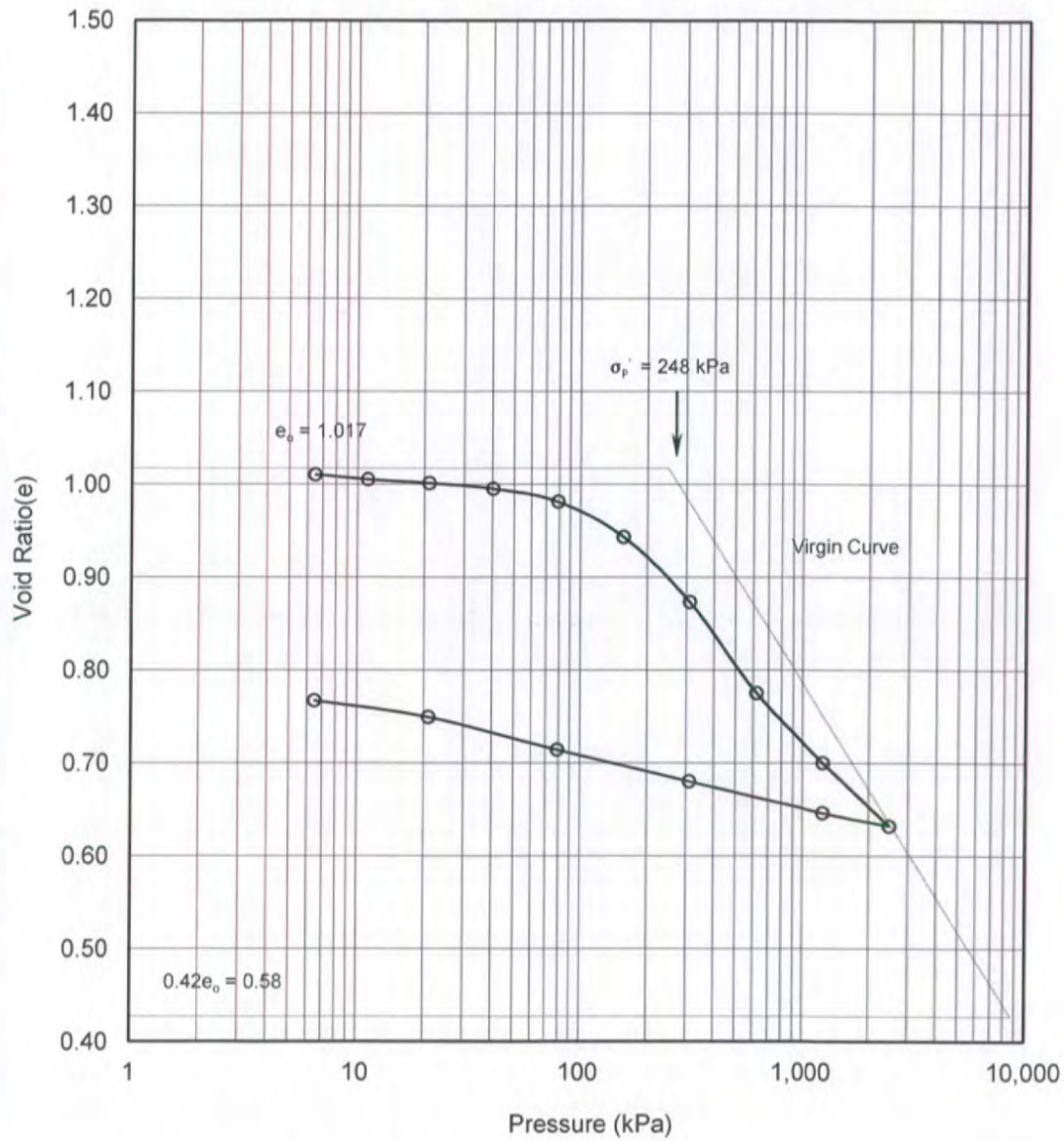
Prepared By : SD
Checked By : RA

CONSOLIDATION TEST

FIGURE B1-21

CALAMITY CREEK CULVERT Site 47-273C

BH 3, TW 22



Soil Type : SILTY CLAY to CLAY

$e_0 =$	1.02	$\omega_L =$	32%	$\sigma_{v0}' =$	265.2 kPa
$\omega =$	50%	$\omega_P =$	20%	$\sigma_p' =$	248.0 kPa
$\gamma =$	18.2 kN/m ³	PI =	12%	$C_c =$	0.382
Gs =	2.72			$C_r =$	0.053

Project No. : 11-14-4066
Date : January 2015



Terraprobe Inc.

Prepared By : SD
Checked By : RA

Z:\11-Project Files\11-Geo\2014\11-14-4066 New Likard Area\11- Calamity Creek Culvert Hwy 11 (47-273C)\KG- Eng Analysis\Spread Sheets\Consolidation Results (Golden).xls

CONSOLIDATION TEST SUMMARY					FIGURE B1-22		
SAMPLE IDENTIFICATION							
Borehole No. :		1		Sample No. :		TW4	
				Sample Depth (m) :		3.0 - 3.5	
TEST CONDITIONS							
Test Type :		Laboratory Standard		Date Started :		1-Oct-14	
Load Duration (hr) :		24		Date Completed :		16-Oct-14	
SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL							
Sample Height (mm) :		25.27		Unit Weight (kN/m ³) :		17.00	
Sample Diameter (mm) :		63.35		Dry Unit Weight (kN/m ³) :		11.14	
Area (cm ²) :		31.52		Specific Gravity :		2.70	
Volume (cm ³) :		79.65		Solid Height (mm) :		10.64	
Water Content (%) :		52.60		Volume of Solids (cm ³) :		33.56	
Wet Mass (g) :		138.07		Volume of Voids (cm ³) :		46.10	
Dry Mass (g) :		90.50		Degree of Saturation (%) :		103.20	
TEST COMPUTATIONS							
Stress	Initial Height	Final Height	Void Ratio	t ₉₀	C _v	m _v	k
(kPa)	(mm)	(mm)		(min)	(cm ² /s)	(m ² /kN)	(cm/s)
1.2	25.27	25.27	1.38				
18.4	25.27	25.18	1.37	5.063	4.43E-03	1.98E-04	8.60E-08
35.6	25.18	25.09	1.36	5.063	4.40E-03	2.22E-04	9.60E-08
69.9	25.09	24.95	1.35	3.063	7.19E-03	1.55E-04	1.10E-07
138.7	24.95	24.75	1.33	3.063	7.08E-03	1.21E-04	8.40E-08
276.1	24.75	24.18	1.27	4	5.19E-03	1.66E-04	8.40E-08
551.0	24.18	21.91	1.06	49	3.50E-04	3.42E-04	1.20E-08
1100.7	21.91	20.73	0.95	10.56	1.45E-03	9.80E-05	1.40E-08
2200.3	20.73	19.82	0.86	10.56	1.33E-03	4.00E-05	5.20E-09
276.1	19.82	20.05	0.97				
69.9	20.05	20.39	1.00				
18.4	20.39	20.79	1.04				
SAMPLE DIMENSIONS AND PROPERTIES _ FINAL							
Sample Height (mm) :		20.79		Unit Weight (kN/m ³) :		18.11	
Sample Diameter (mm) :		63.35		Dry Unit Weight (kN/m ³) :		13.61	
Area (cm ²) :		31.52		Specific Gravity :		2.70	
Volume (cm ³) :		65.52		Solid Height (mm) :		10.64	
Water Content (%) :		33.10		Volume of Solids (cm ³) :		33.72	
Wet Mass (g) :		120.99		Volume of Voids (cm ³) :		31.81	
Dry Mass (g) :		90.93					
Project No. : 11-14-4066				Prepared By : SD			
Date : January 2015				Checked By : RA			



Terraprobe Inc.

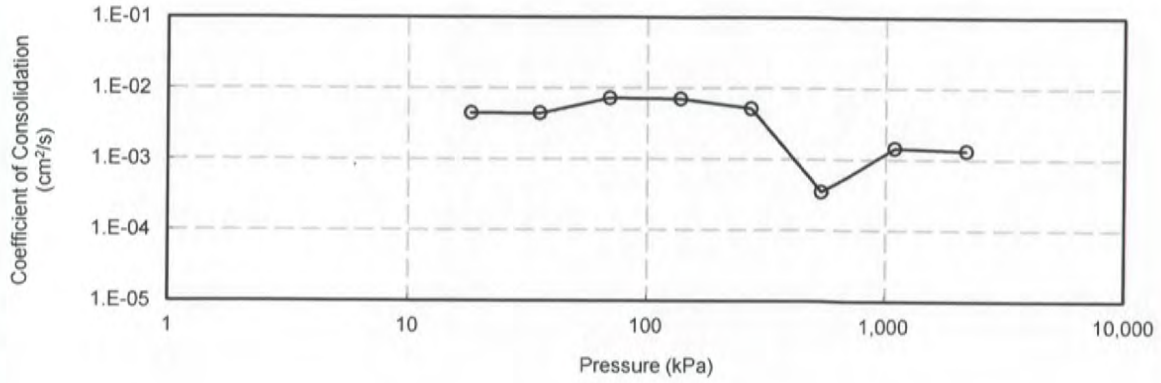
CONSOLIDATION TEST

FIGURE B1-23

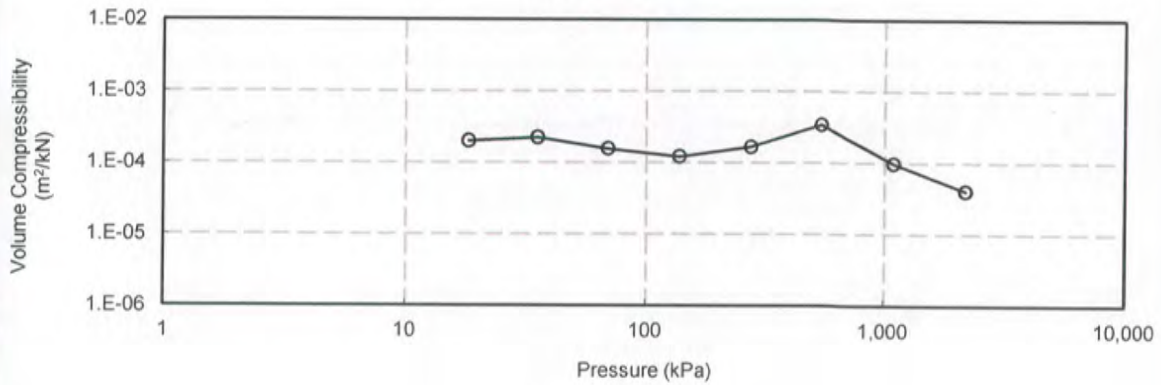
CALAMITY CREEK CULVERT(Site 47-273C)

BH 1, TW 4

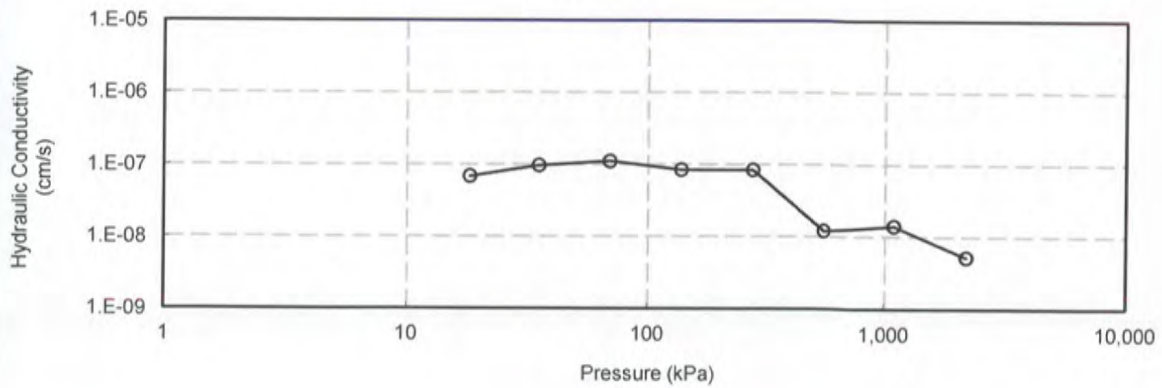
Cv vs Pressure



mv vs Pressure



k vs Pressure



Project No. : 11-14-4066
Date : December 2014



Terraprobe Inc.

Prepared By : SD
Checked By : RA

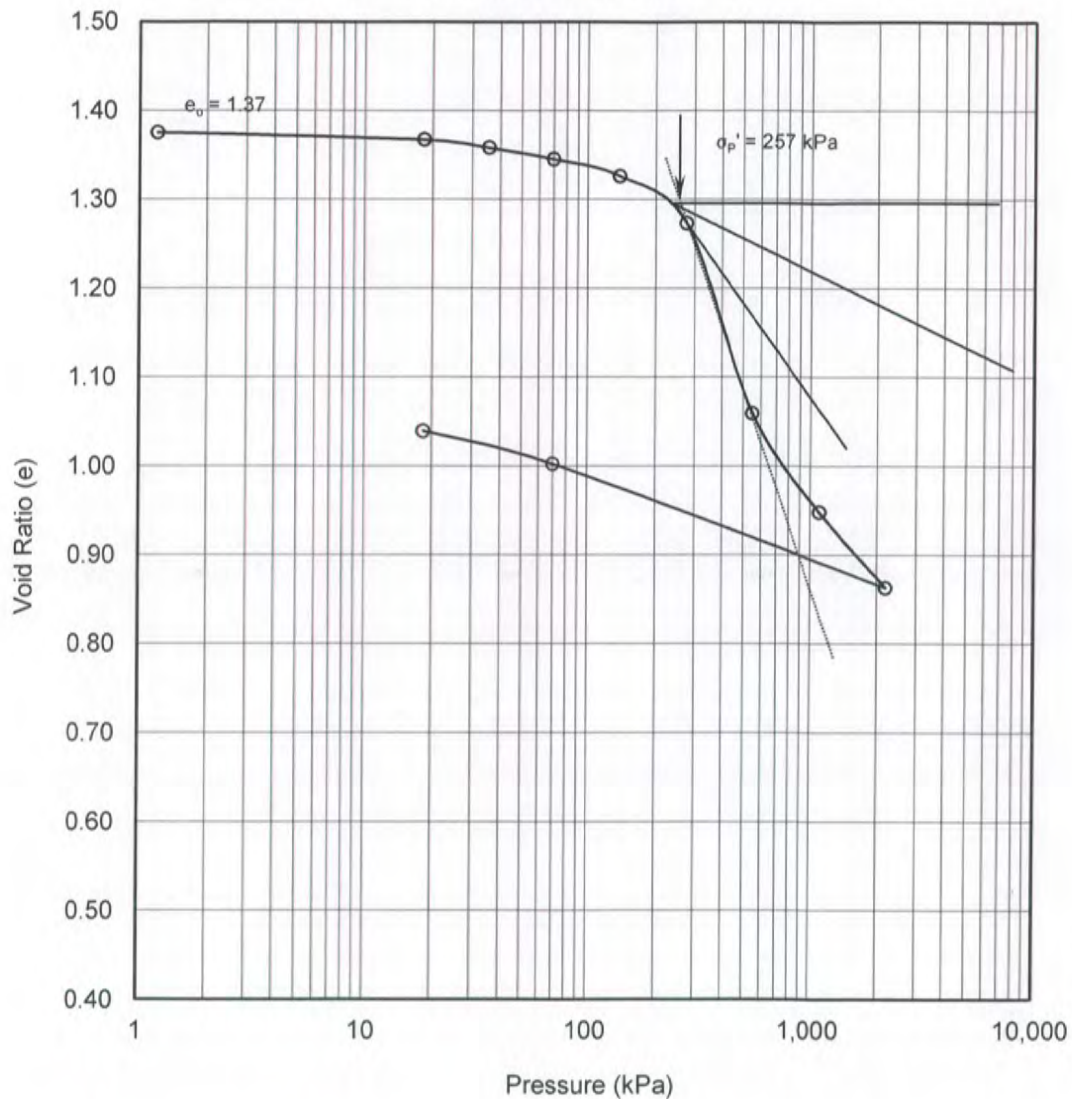
CONSOLIDATION TEST

FIGURE B1-24

CALAMITY CREEK CULVERT (Site 47-273C)

BH 1, TW 4

Void Ratio vs Pressure



Soil Type : SILTY CLAY to CLAY

$e_o =$	1.38	$\omega_L =$	31%	$\sigma_{v0}' =$	39.5 kPa
$\omega =$	53%	$\omega_p =$	19%	$\sigma_p' =$	257.0 kPa
$\gamma =$	17.0 kN/m ³	PI =	12%		
Gs =	2.70				

Project No. : 11-14-4066
Date : January 2015

 **Terraprobe Inc.**

Prepared By : SD
Checked By : RA

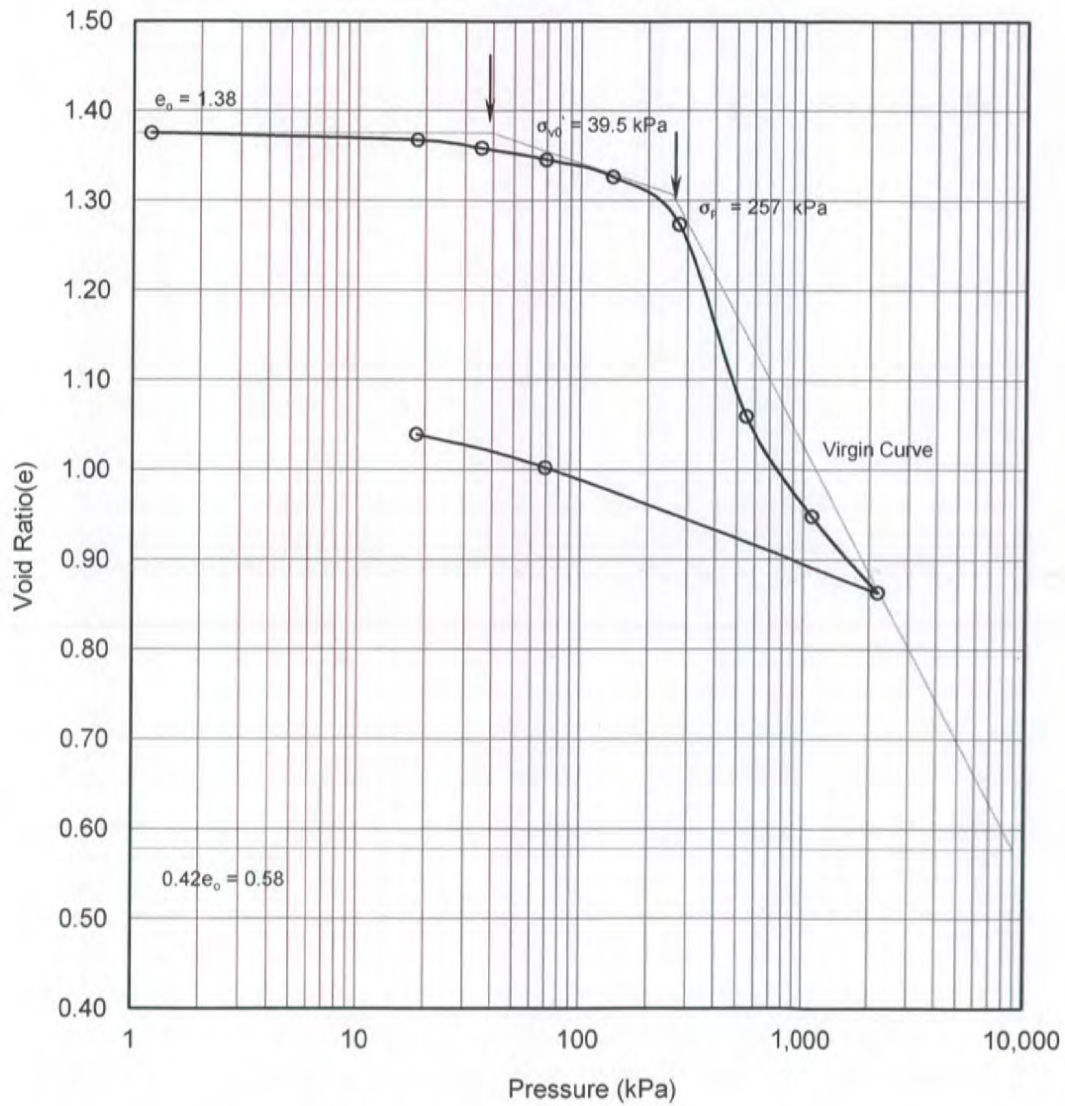
CONSOLIDATION TEST

FIGURE B1-25

CALAMITY CREEK CULVERT(Site 47-273C)

BH 1, TW 4

Void Ratio vs Pressure



Soil Type : SILTY CLAY to CLAY

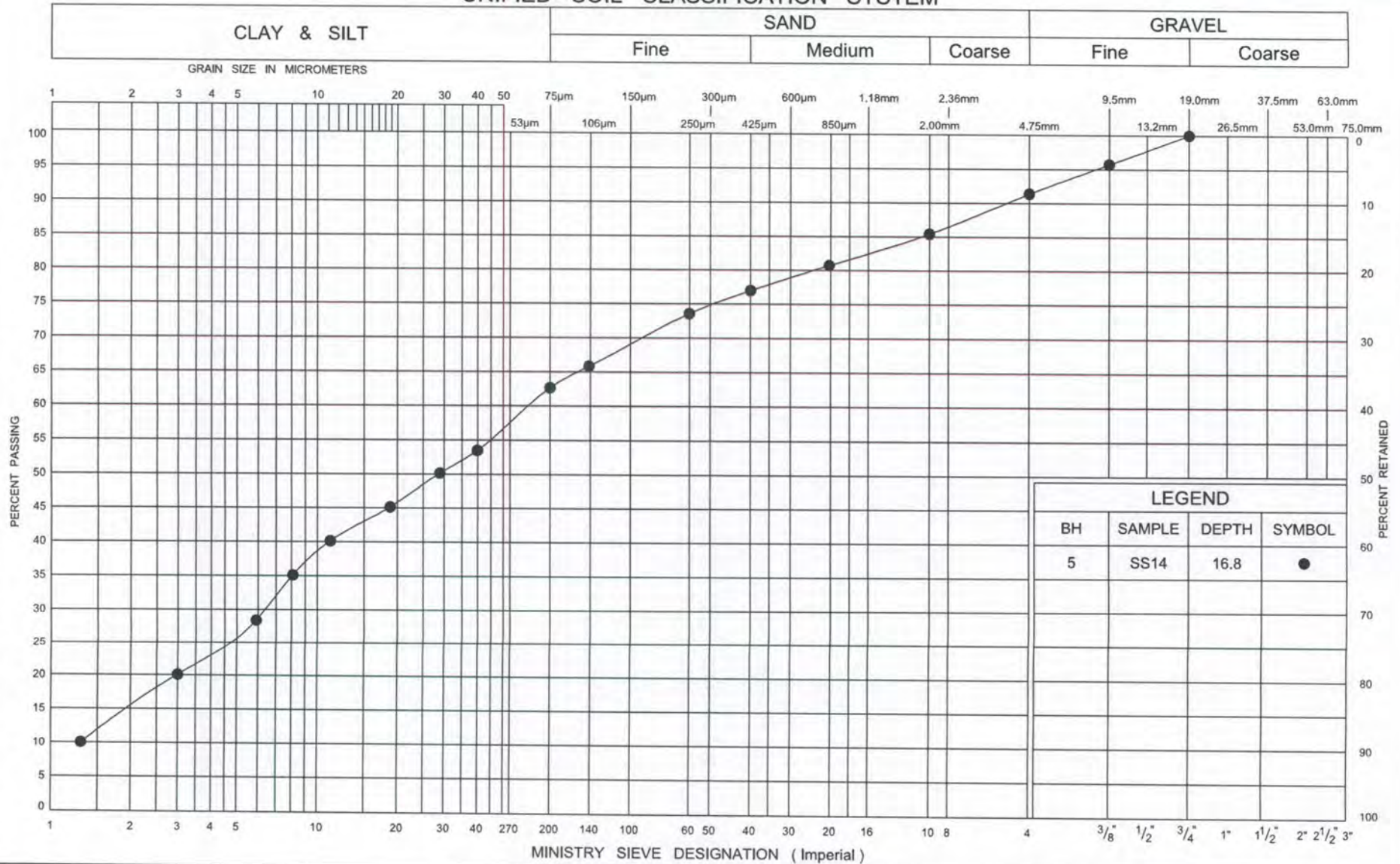
$e_o =$	1.38	$\omega_L =$	31%	$\sigma'_{v0} =$	39.5 kPa
$\omega =$	53%	$\omega_P =$	19%	$\sigma'_p =$	257.0 kPa
$\gamma =$	17.0 kN/m ³	PI =	12%	$C_c =$	0.472
$G_s =$	2.70			$C_r =$	0.085

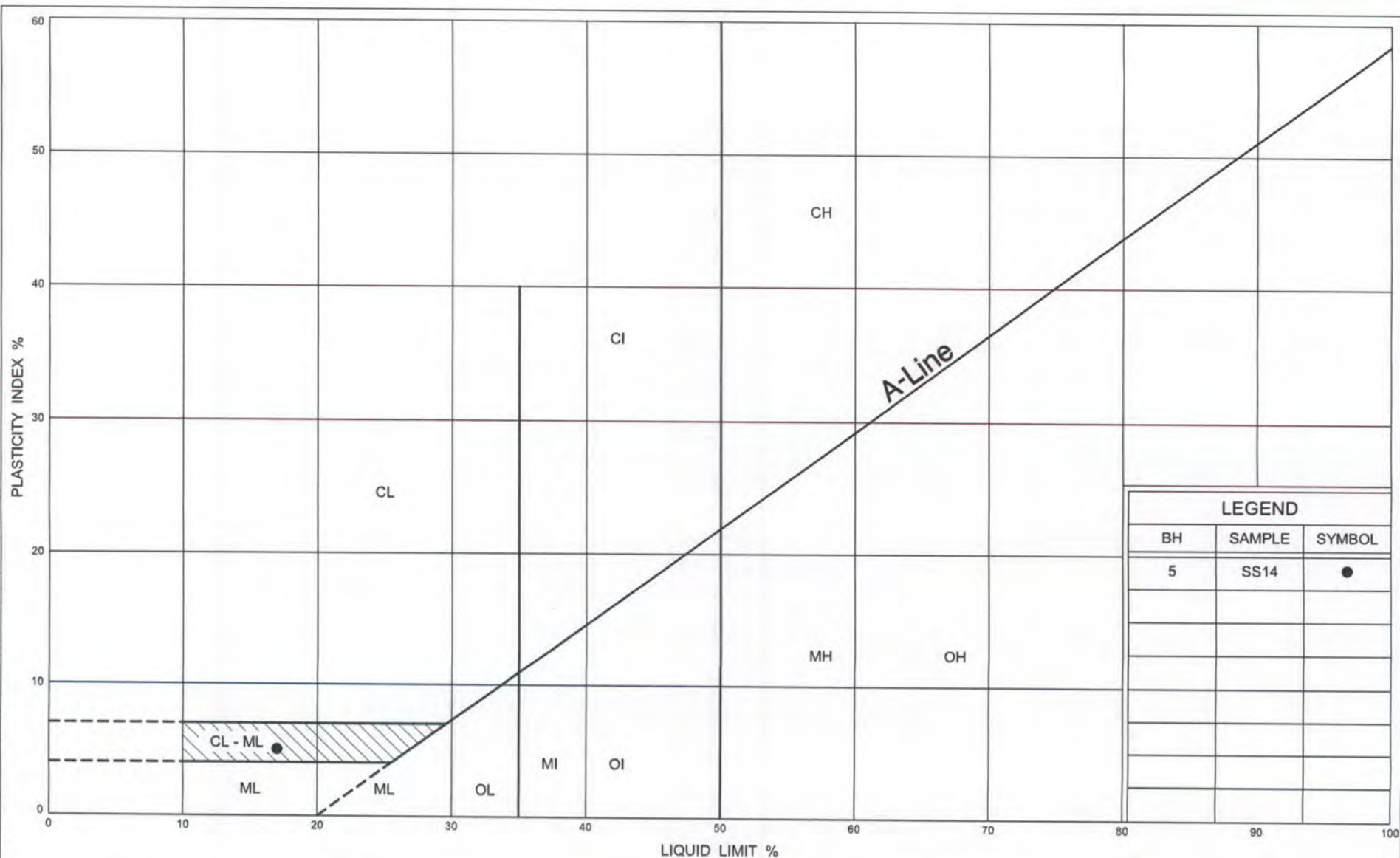
Project No. : 11-14-4066
Date : January 2015



Prepared By : SD
Checked By : RA

UNIFIED SOIL CLASSIFICATION SYSTEM





Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT TILL

FIG No B1-27

G W P 5159-12-00

Calamity Creek Culvert (47-273C)

RECORD OF BOREHOLE No 16-1

1 OF 1

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 287.6 E 404 445.1 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.11 - 2016.08.11 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W P W W L					
194.3							20 40 60 80 100							
0.0	TOPSOIL (100 mm)						20 40 60 80 100							
0.1	CLAY stiff brown		1	SS	7									
193.2			2	SS	16									
1.1	CLAY, varved firm to stiff grey													
			3	SS	1									
			4	SS	1									
			5	SS	1									
			6	SS	2									
													</	

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
5
10
(%) STRAIN AT FAILURE



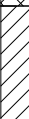

ONTMT4S 19-5161-208 CALAMITY CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 23/3/17

RECORD OF BOREHOLE No 16-2

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 303.9 E 404 471.5 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.10 - 2016.08.10 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
200.5							20 40 60 80 100						
0.0							20 40 60 80 100						
0.1	TOPSOIL (100 mm)		1	SS	15								
	Clayey SAND loose brown FILL												
199.6			2	SS	8								
0.9	CLAY firm brown												
198.8													
1.7	CLAY, varved firm to stiff grey		3	SS	2								
			4	SS	2								
			5	SS	1								
			6	SS	3								
			7	SS	2								

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-2

2 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 303.9 E 404 471.5 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.10 - 2016.08.10 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
	Continued From Previous Page							20 40 60 80 100		W _P W W _L			GR SA SI CL	
	CLAY, varved firm to stiff grey						190	5.0 + 4.0 +					0 0 61 39	
			9	SS	1		189	6.7 + 5.8 +						
			10	SS	4		188							
							187	4.8 + 4.4 +						
186.5			11	SS	4		186							
14.0	Clayey SAND loose grey TILL		12	SS	100/ 250mm								14 41 28 17	
185.8														
14.7	Borehole terminated on inferred bedrock at 14.7 m Borehole open upon completion Water in borehole at 0.45 m upon completion													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-3

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 323.0 E 404 488.4 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.11 - 2016.08.12 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
203.2								20	40	60	80	100						
0.0	TOPSOIL (100 mm)																	
0.1	Clayey SAND compact brown FILL		1	SS	24		203											
			2	SS	21		202											
201.7																		
1.5	CLAY firm brown FILL		3	SS	2		201											
			4	SS	2		200											
199.5																		
3.7	CLAY stiff brown						199											
			5	SS	4		198											
							197											
197.0																		
6.2	CLAY, varved firm to stiff grey		6	SS	1		196											
			7	SS	7		195											
			8	SS	4		194											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE				SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W P W W L			
Continued From Previous Page													
186.6 16.6	CLAY, varved firm to stiff grey						193	4.5 +	10.0 +				
			9	SS	2		192	8.4 +	6.9 +				
			10	SS	3		191						
							190	5.0 +	4.2 +				
			11	SS	4		189	7.7 +	3.3 +				
							188						
			12	SS	5		187	4.3 +	4.7 +				
							186						
185.9 17.3	Clayey SAND loose grey TILL		13	SS	10								
Borehole terminated on inferred bedrock at 17.3 m Borehole open to 16.4 m upon completion Water in piezometer at 1.2 m on August 16, 2016													

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-4

1 OF 3

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 372.9 E 404 540.7 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.08 - 2016.08.09 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
213.4								20 40 60 80 100						
0.0 213.1	ASPHALT (260 mm)													
0.3 212.5	SAND with silt and gravel brown FILL		1	AS			213							
0.9 212.2	ASPHALT (280 mm)		2	SS	100									
1.2 211.1	SAND with silt and gravel, occasional cobbles and boulders loose FILL -280 mm diameter boulder at 1.8 m		3	SS	100/ 180 mm		212							
2.3	Clayey SAND with gravel brown loose FILL		4	SS	4		211							
			5	SS	5		210							14 43 26 17
			6	SS	4		209							
			7	SS	4		208							
			8	SS	7		207							30 35 25 10
			9	SS	6		206							
							205							
204.3 9.1	Clay firm brown to grey FILL -25 mm fine fibrous organic layer at 9.6 m		10	SS	7		204							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-4

2 OF 3

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 372.9 E 404 540.7 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.08 - 2016.08.09 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100				
								20 40 60 80 100				
	Continued From Previous Page											
201.8	Clay firm brown to grey FILL -150 mm diameter cobble at 10.7 m -trace wood pieces		11	SS	10							
11.6	CLAY, trace roots/wood stiff greyish brown		12	SS	11							
200.0												
13.4	CLAY, varved firm to stiff grey		13	SS	WH							
			14	ST	PUSH							
			15	SS	WH							
			16	SS	1							
									</			

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-4

3 OF 3

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 372.9 E 404 540.7 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.08 - 2016.08.09 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			
								○ UNCONFINED	+	FIELD VANE									
								● QUICK TRIAXIAL	×	LAB VANE									
Continued From Previous Page								20	40	60	80	100	20	40	60				
	CLAY, varved firm to stiff grey		17	SS	WH		193												
			18	ST	PUSH		192												
			19	SS	1		191												
							190												

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
10
20
30
40
50
60
70
80
90
100
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-5

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 411.0 E 404 578.4 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.14 - 2016.08.15 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
204.0								20	40	60	80	100					
0.0	TOPSOIL (50 mm)																
0.1	Clayey SAND with gravel, occasional cobble compact to loose brown FILL		1	SS	22									○			19 49 32 (SI+CL)
			2	SS	18												
				3	SS	13											
				4	SS	4								○			
			5	SS	4												
			6	SS	7									○			
199.6																	
4.4	Clay stiff grey FILL		7	SS	15										○		
			8	SS	15												
197.9	-trace roots/organics at 6.1 m																
6.1	CLAY, varved firm to stiff grey		9	SS	4										┌───┐ c		0 0 39 61
				10	SS	3										○	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-6

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 437.6 E 404 603.8 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.14 - 2016.08.14 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100				
198.1								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
0.0	TOPSOIL (50 mm)		1	SS	25		198	20 40 60 80 100				
	CLAY stiff brown							PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L				
197.2			2	SS	9		197	WATER CONTENT (%) 20 40 60				
0.9	CLAY, varved firm to stiff grey											
			3	SS	1		196					
			4	SS	WH		195					
							194					
			5	SS	1		193					
			6	SS	1		192					
			7	SS	4		191					
							190					
							189					
188.4			8	SS	9							
9.7	Borehole terminated on inferred bedrock at 9.7 m											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 19-5161-208 CALAMITY CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 23/3/17

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-7

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 343.6 E 404 499.5 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.12 - 2016.08.13 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								RESISTANCE PLOT					
								WATER CONTENT (%)					
204.2													
0.0	TOPSOIL (100 mm)												
0.1	Clayey SAND with gravel, occasional cobbles very dense brown FILL		1	SS	58								
			2	SS	109								
203.0													
1.2	Clay firm brown to grey FILL		3	SS	7								
			4	SS	2								
			5	SS	1								
			6	SS	2								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S 19-5161-208 CALAMITY CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 23/3/17

RECORD OF BOREHOLE No 16-7

2 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 343.6 E 404 499.5 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.12 - 2016.08.13 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
Continued From Previous Page							WATER CONTENT (%) 20 40 60							
							194							
			10	SS	5									
								2.7 +						
								4.3 +						
192.0							192							
12.2	CLAY with sand, varved firm to stiff grey		11	SS	1									
								8.0 +						
								8.3 +						
			12	SS	3									6 17 39 38
								6.4 +						
								5.7 +						
			13	SS	6		189							
								4.5 +						
							188							
								4.6 +						
			14	SS	8		187							
186.8														
17.4	Clayey SAND compact brownish-grey TILL		15	SS	25									
186.2														
18.0	Borehole terminated on inferred bedrock at 18.0 m Borehole open to 15.8 m upon completion Vibrating Wire Piezometer installed at 14.9 m													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-8

1 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 397.6 E 404 565.3 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.15 - 2016.08.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
206.9								20 40 60 80 100						
0.0								20 40 60 80 100						
0.1	TOPSOIL (50 mm)		1	SS	32									
	Clayey SAND with gravel, occasional cobbles loose to dense brown FILL		2	SS	19		206							
			3	SS	19		205							
			4	SS	9		204							14 47 30 9
			5	SS	12									
							203							
			6	SS	16		202							
							201							
			7	SS	17									
							200							
199.6														
7.3	Clay firm brown to grey FILL		8	SS	41		199							21 42 23 14
198.2														
8.7	CLAY, varved firm to stiff grey						198							0 2 33 65
			9	SS	8									
							197							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

ONTMT4S 19-5161-208 CALAMITY CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 23/3/17

RECORD OF BOREHOLE No 16-8

2 OF 2

METRIC

GWP# 5013-E-0031 LOCATION Calamity Creek Culvert, MTM Z12: N 5 269 397.6 E 404 565.3 ORIGINATED BY JG
 HWY 11 BOREHOLE TYPE NW casing COMPILED BY JG
 DATUM Geodetic DATE 2016.08.15 - 2016.08.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE							
								● QUICK TRIAXIAL	× LAB VANE							
	Continued From Previous Page							20 40 60 80 100								
	CLAY, varved firm to stiff grey							8.7 +								
		10	SS	3				14.4 +								
								5.3 +								
								8.7 +								
			11	SS	3											
			12	SS	WH			8.0 +								
								7.5 +								
								5.6 +								
								4.7 +								
			13	SS	5											
								6.6 +								
								4.0 +								
			14	SS	8											
	-silty															
			15	SS	8											

+³, ×³: Numbers refer to
Sensitivity

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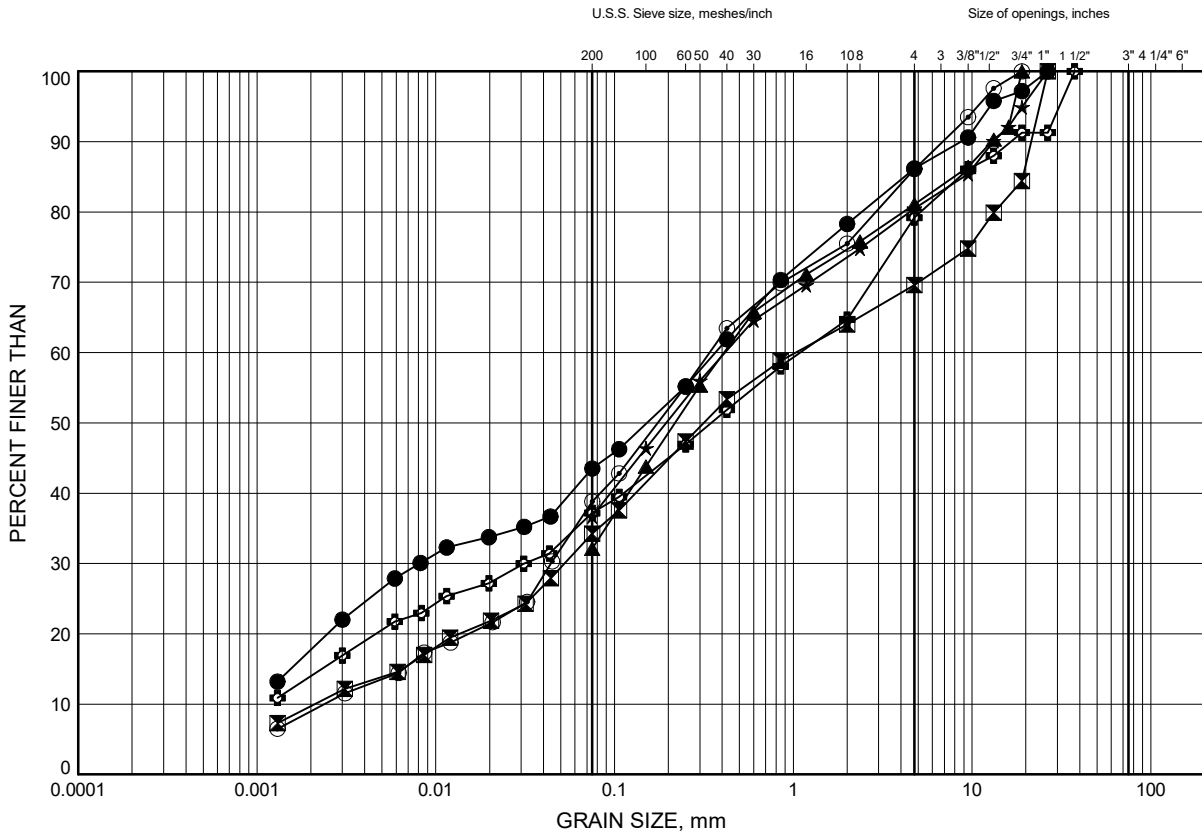
(%) STRAIN AT FAILURE

ONTMT4S 19-5161-208 CALAMITY CREEK CULVERT.GPJ 2012TEMPLATE(MTO).GDT 23/3/17

Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C1

Clayey SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	3.35	210.05
⊠	16-4	6.40	207.00
▲	16-5	0.30	203.70
★	16-7	0.91	203.29
⊙	16-8	2.59	204.31
⊕	16-8	6.40	200.50

Date ..October 2016.....

GWP# ..5013-E-0031.....



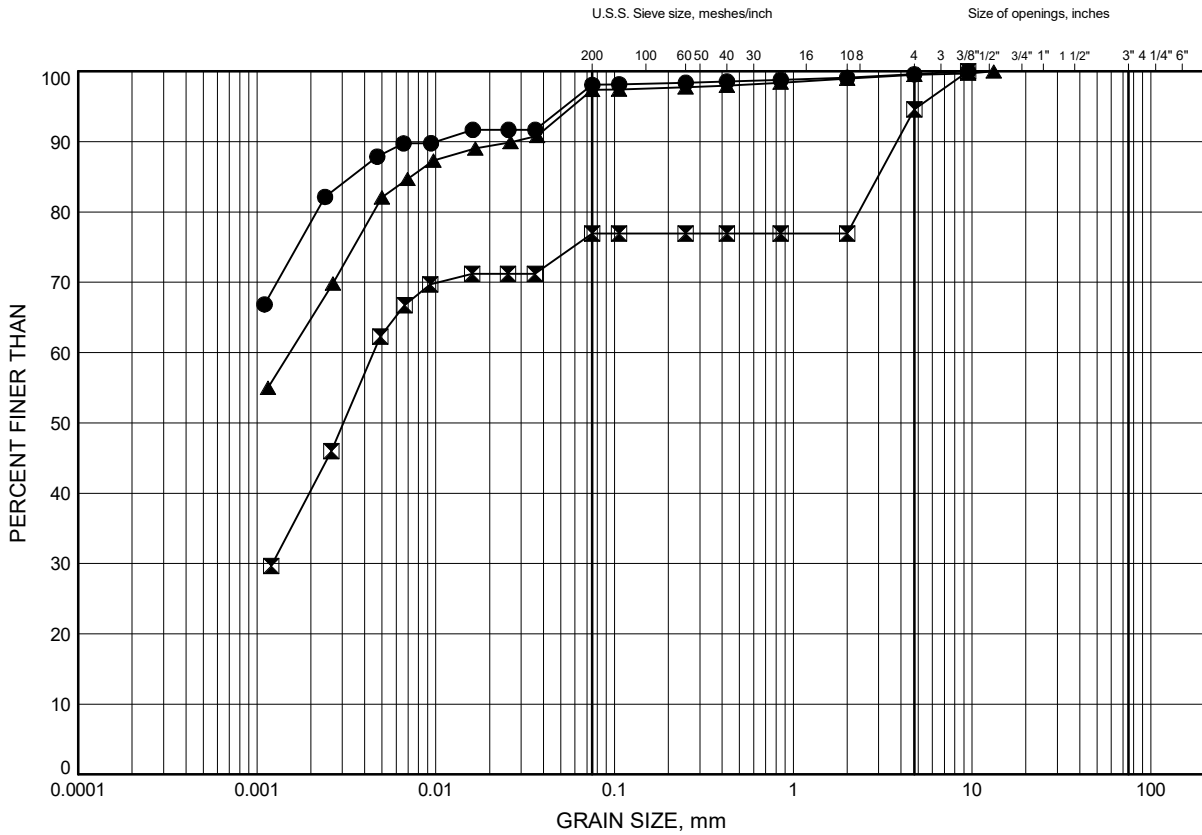
Prep'dSBP.....

Chkd.FJG.....

Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

CLAY FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-3	3.35	199.85
⊠	16-7	4.88	199.32
▲	16-8	7.92	198.98

Date ..October 2016.....

GWP# ..5013-E-0031.....

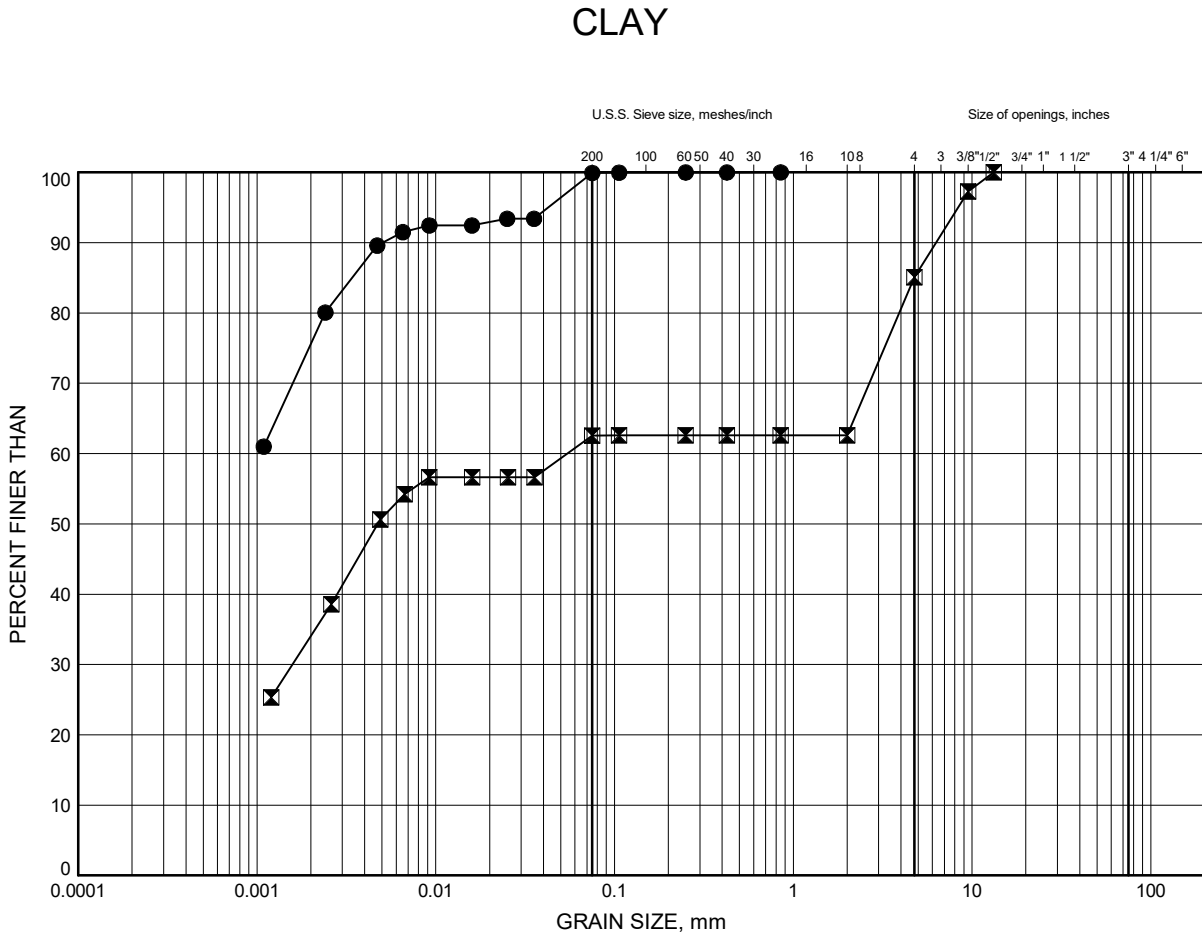


Prep'd ..SBP.....

Chkd.FJG.....

Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	12.50	200.90
⊠	16-7	9.45	194.75

Date ..October 2016.....

GWP# ..5013-E-0031.....



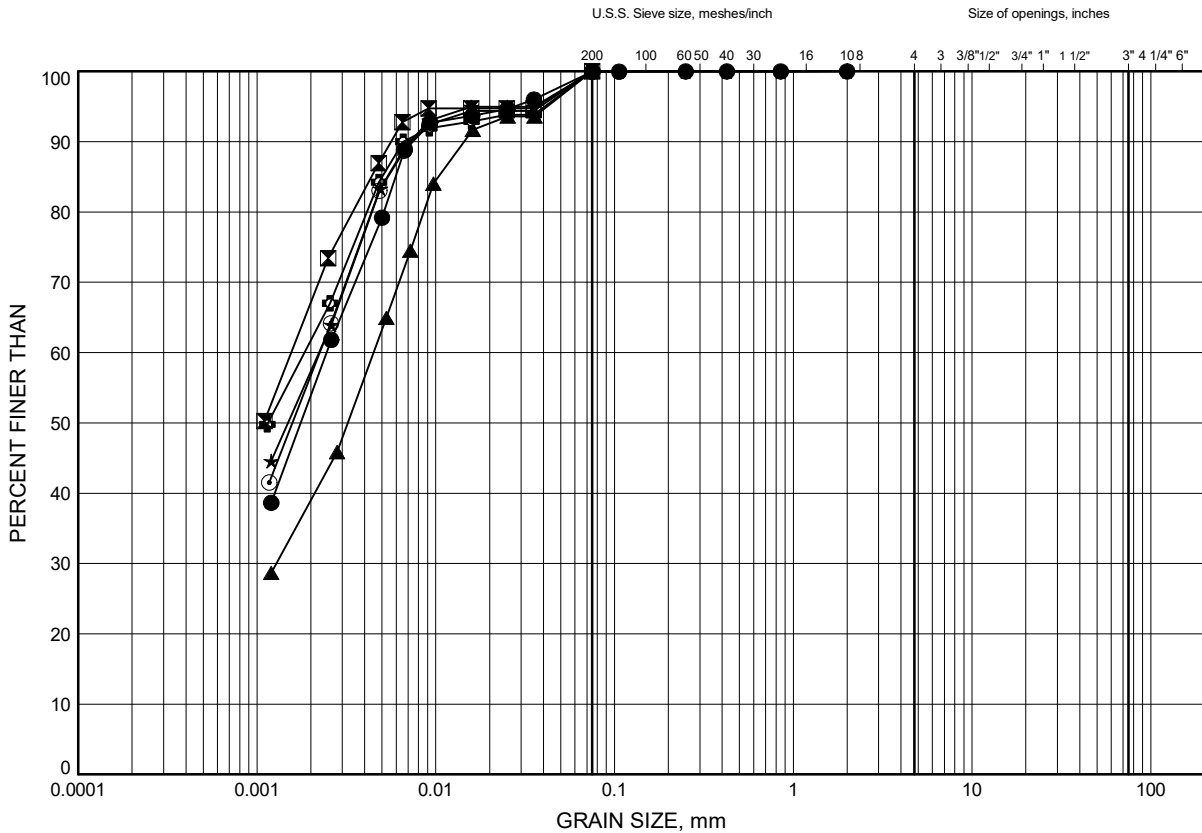
Prep'd ..SBP.....

Chkd.FJG.....

Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C4

CLAY (Varved)



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	3.35	190.95
⊠	16-2	4.88	195.62
▲	16-2	10.97	189.53
★	16-3	7.92	195.28
⊙	16-3	14.02	189.18
⊕	16-4	17.07	196.33

Date ..October 2016.....

GWP# ..5013-E-0031.....



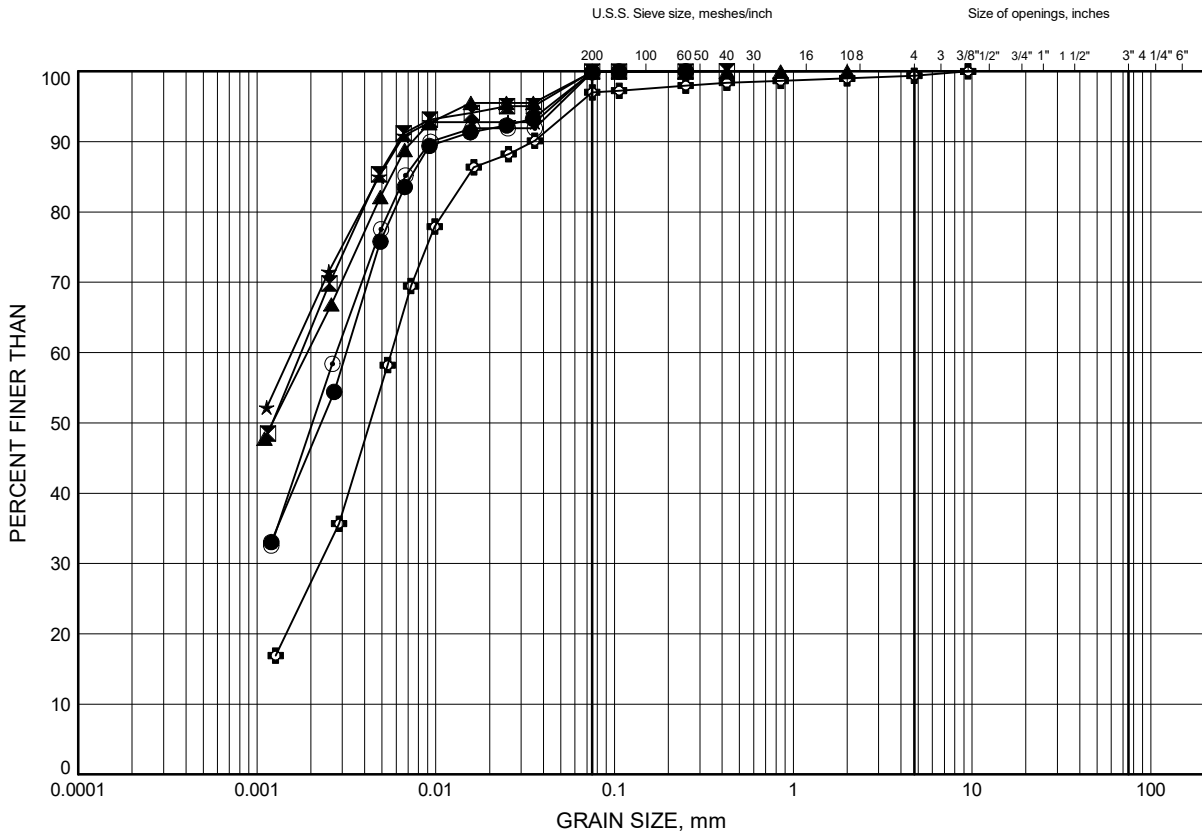
Prep'd ..SBP.....

Chkd.FJG.....

Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C5

CLAY (Varved)



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	21.64	191.76
⊠	16-4	23.16	190.24
▲	16-5	6.40	197.60
★	16-5	12.50	191.50
⊙	16-6	3.35	194.75
⊕	16-6	9.37	188.73

Date ..October 2016.....

GWP# ..5013-E-0031.....



Prep'd ..SBP.....

Chkd.FJG.....

FIGURE C6

PERCENT FINER THAN

GRAIN SIZE, mm

U.S.S. Sieve size, meshes/inch

Size of openings, inches

Grain Size (mm)	Percent Finer (%) - Circles	Percent Finer (%) - Triangles	Percent Finer (%) - Crosses
0.0015	27	16	29
0.003	45	36	57
0.006	61	61	77
0.01	70	81	92
0.02	71	89	93
0.03	71	89	93
0.05	71	91	93
0.075	78	97	100
0.1	78	98	100
0.2	78	99	100
0.3	78	99	100
0.5	78	99	100
1.0	78	100	100
2.0	78	100	100
4.0	95	100	100
6.0	100	100	100

SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-7	14.02	190.18
⊠	16-8	12.50	194.40
▲	16-8	18.59	188.31

Prep'd SBP

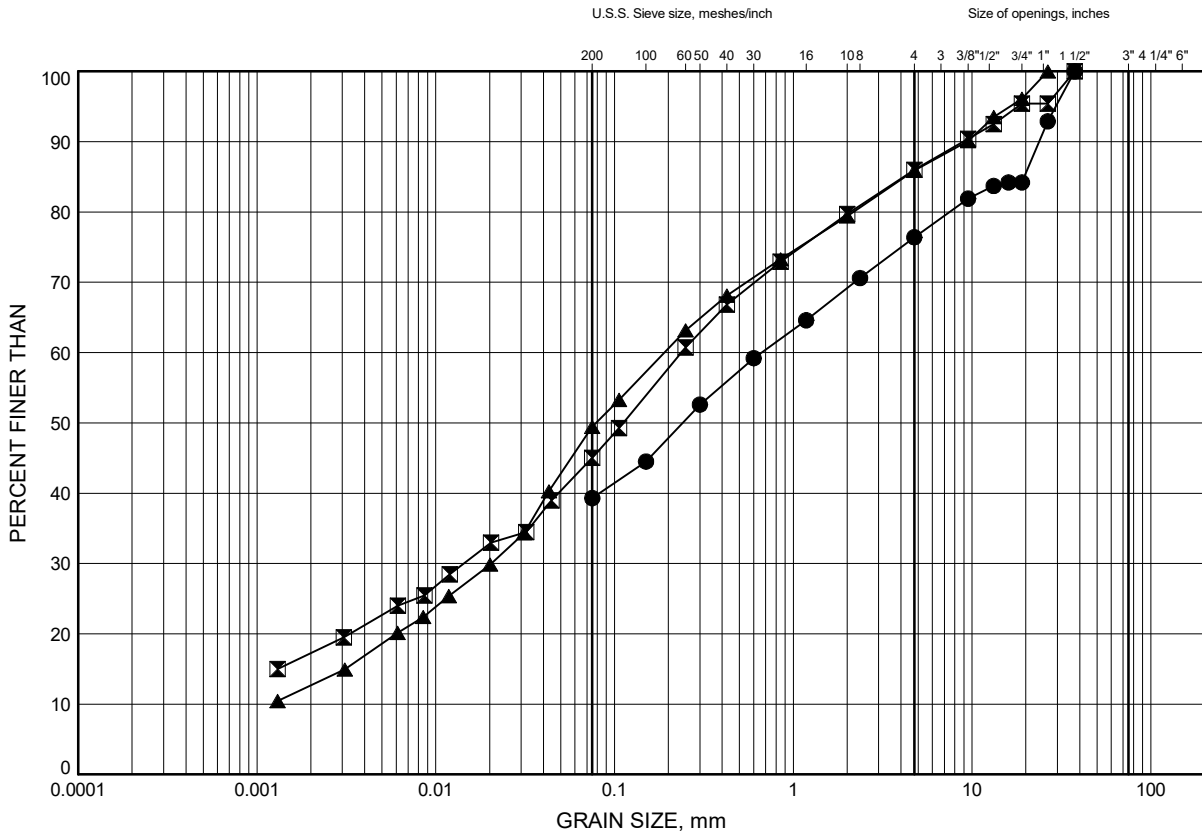
Chkd. FJG



Calamity Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C7

Clayey SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	8.00	186.30
⊠	16-2	14.17	186.33
▲	16-4	26.75	186.65

Date October 2016
GWP# 5013-E-0031

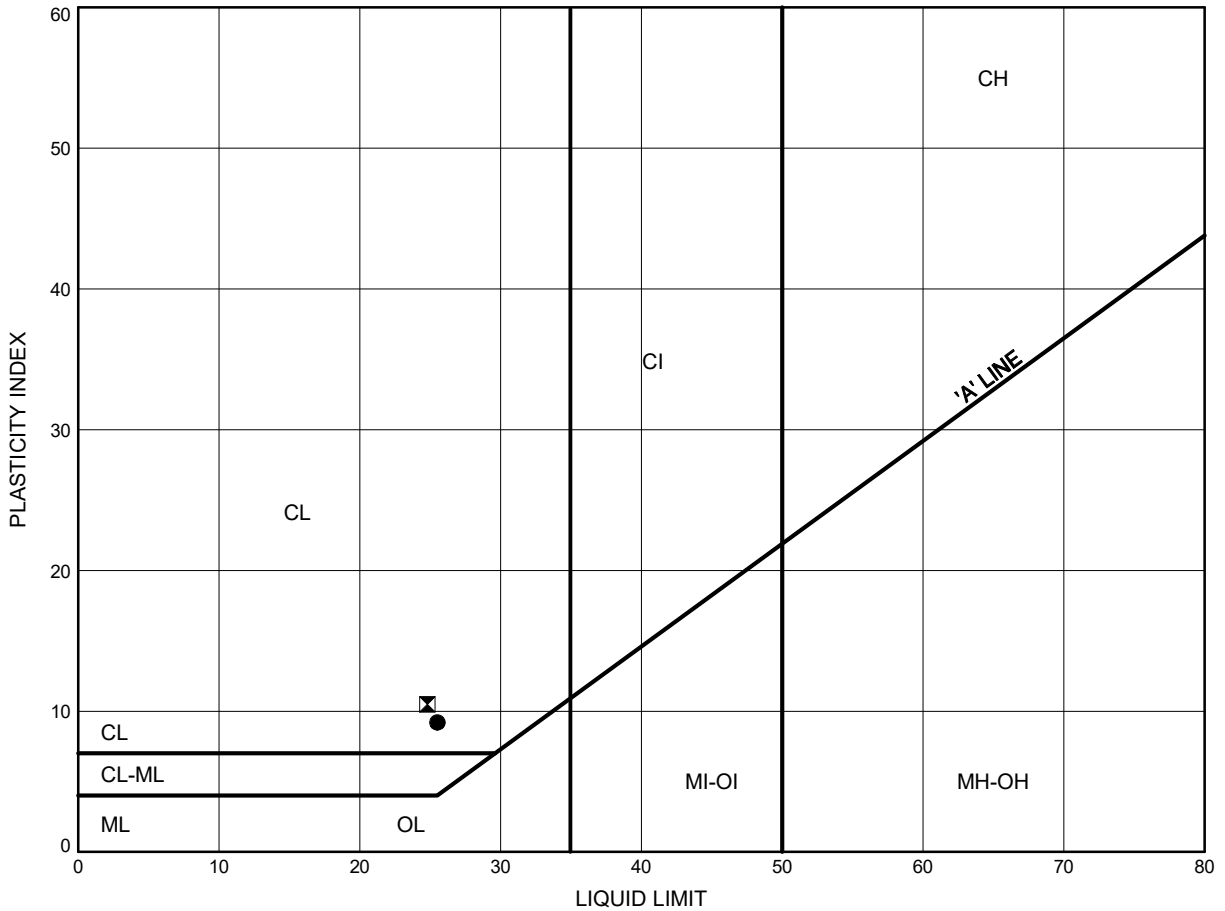


Prep'd SBP
Chkd. FJG

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C8

Clayey SAND FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	3.35	210.05
⊠	16-8	6.40	200.50

Date ..October 2016.....
 GWP# ..5013-E-0031.....

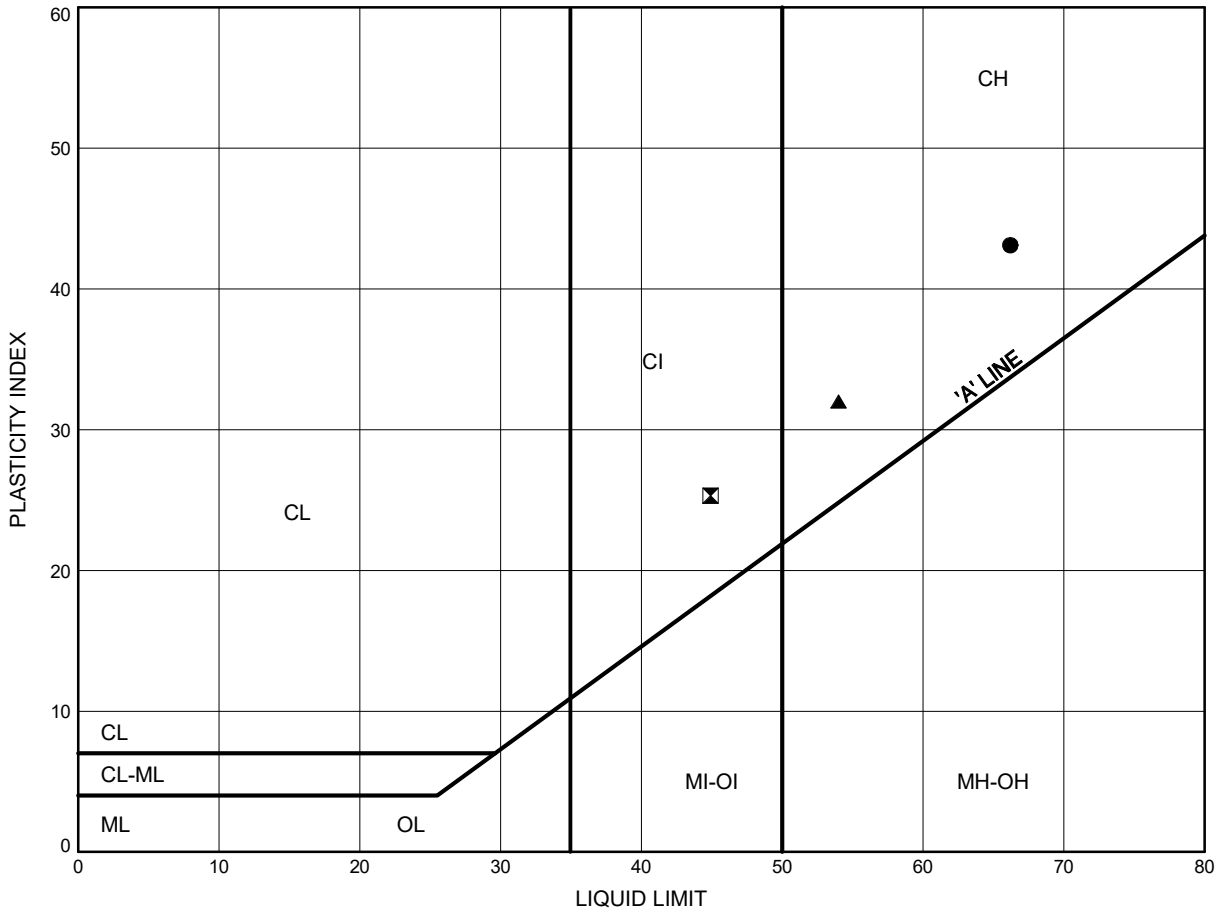


Prep'd ..SBP.....
 Chkd.FJG.....

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C9

CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-3	3.35	199.85
⊠	16-7	4.88	199.32
▲	16-8	7.92	198.98

Date ..October 2016.....

GWP# ..5013-E-0031.....



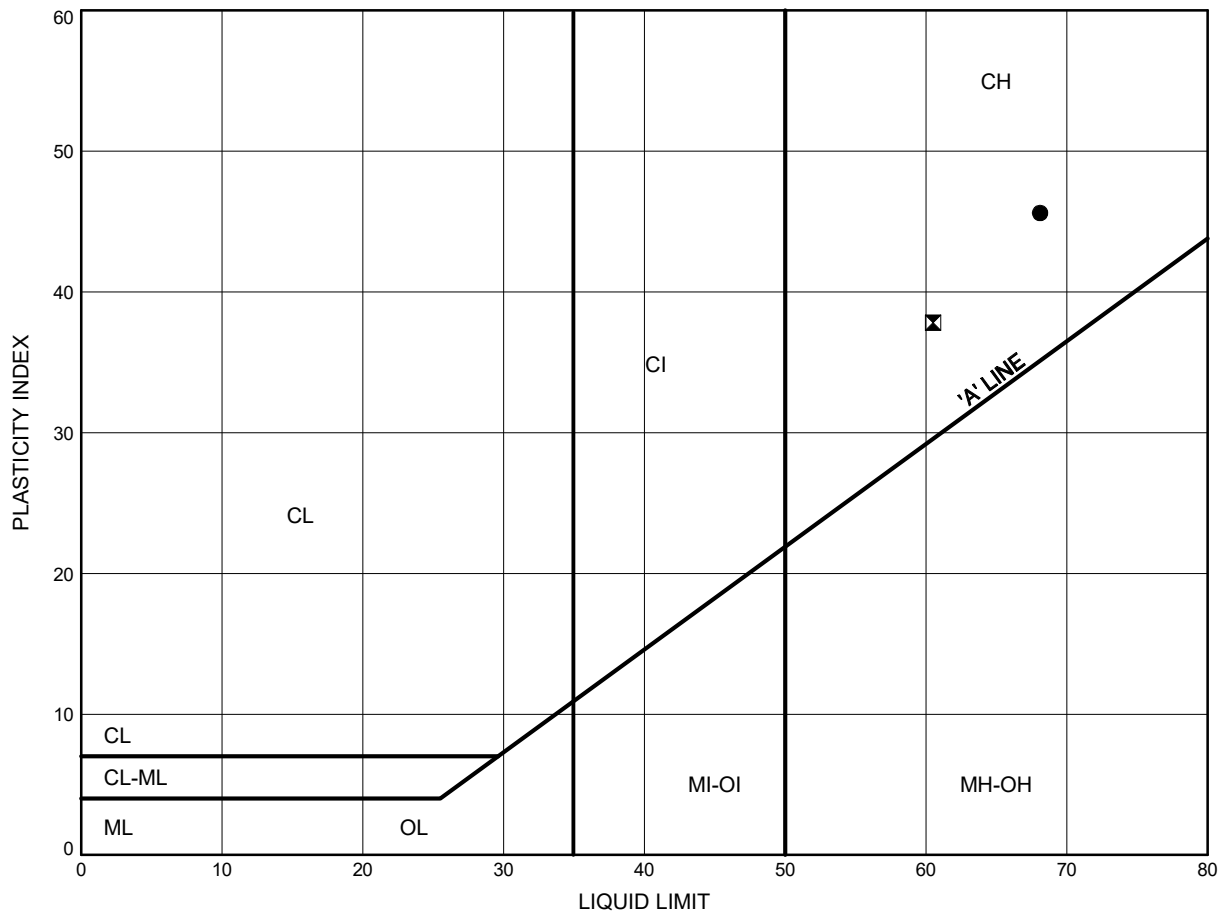
Prep'dSBP.....

Chkd.FJG.....

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C10

CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	12.50	200.90
⊠	16-7	9.45	194.75

Date ..October 2016.....
 GWP# ..5013-E-0031.....

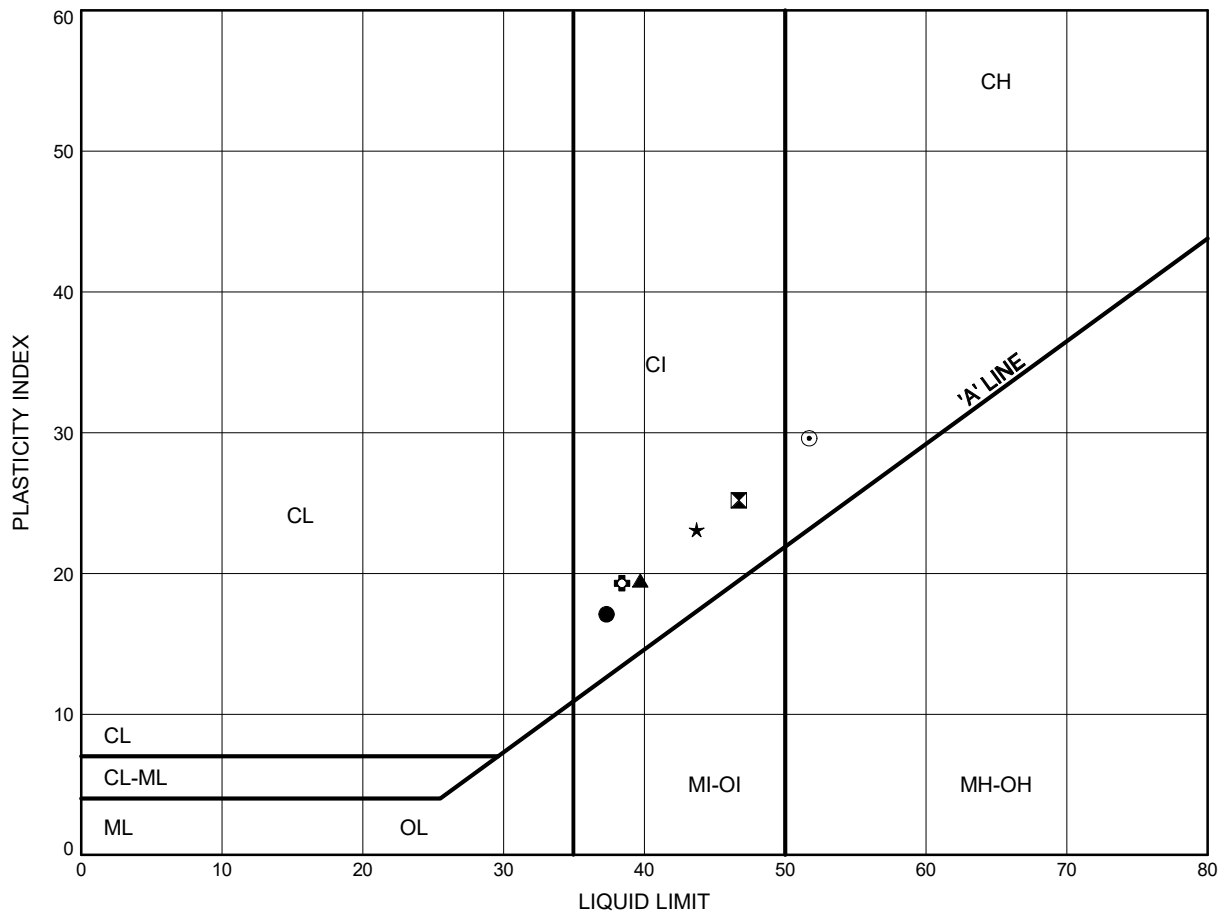


Prep'd ..SBP.....
 Chkd.FJG.....

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C11

CLAY (Varved)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-1	3.35	190.95
⊠	16-2	4.88	195.62
▲	16-2	10.97	189.53
★	16-3	7.92	195.28
⊙	16-3	14.02	189.18
⊕	16-4	17.07	196.33

Date October 2016
 GWP# 5013-E-0031

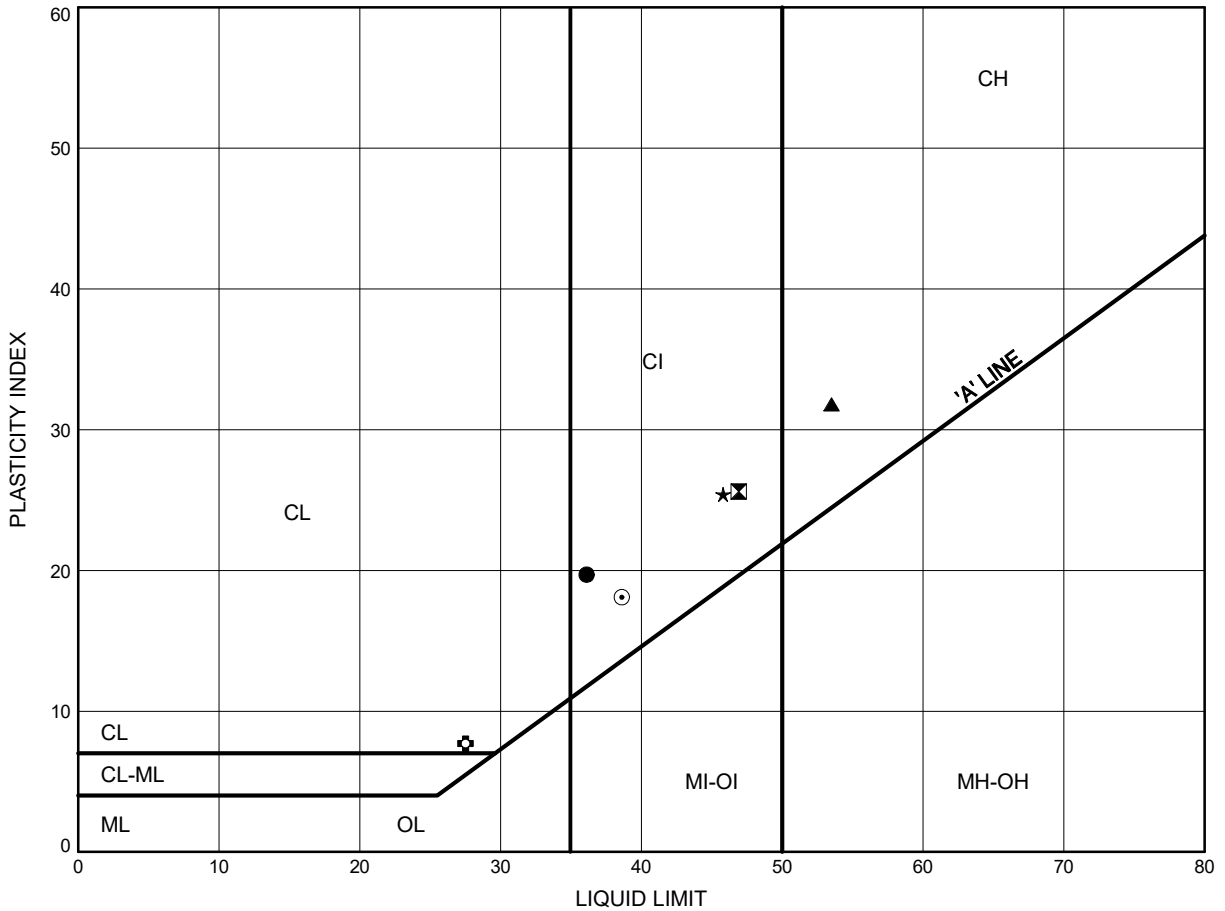


Prep'd SBP
 Chkd. FJG

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C12

CLAY (Varved)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-4	21.64	191.76
⊠	16-4	23.16	190.24
▲	16-5	6.40	197.60
★	16-5	12.50	191.50
⊙	16-6	3.35	194.75
⊕	16-6	9.37	188.73

Date October 2016
 GWP# 5013-E-0031

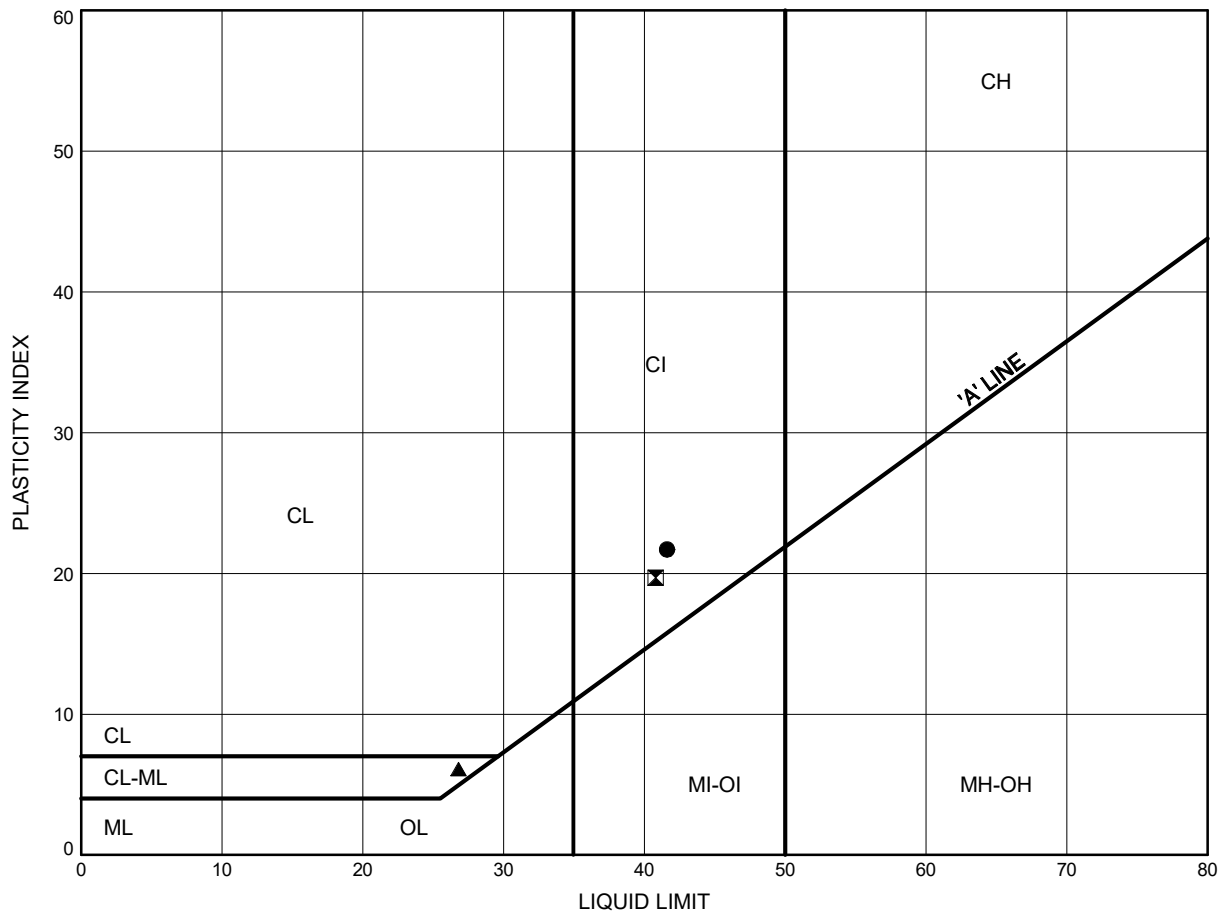


Prep'd SBP
 Chkd. FJG

Calamity Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C13

CLAY (Varved)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-7	14.02	190.18
⊠	16-8	12.50	194.40
▲	16-8	18.59	188.31

Date ..October 2016.....

GWP# ..5013-E-0031.....

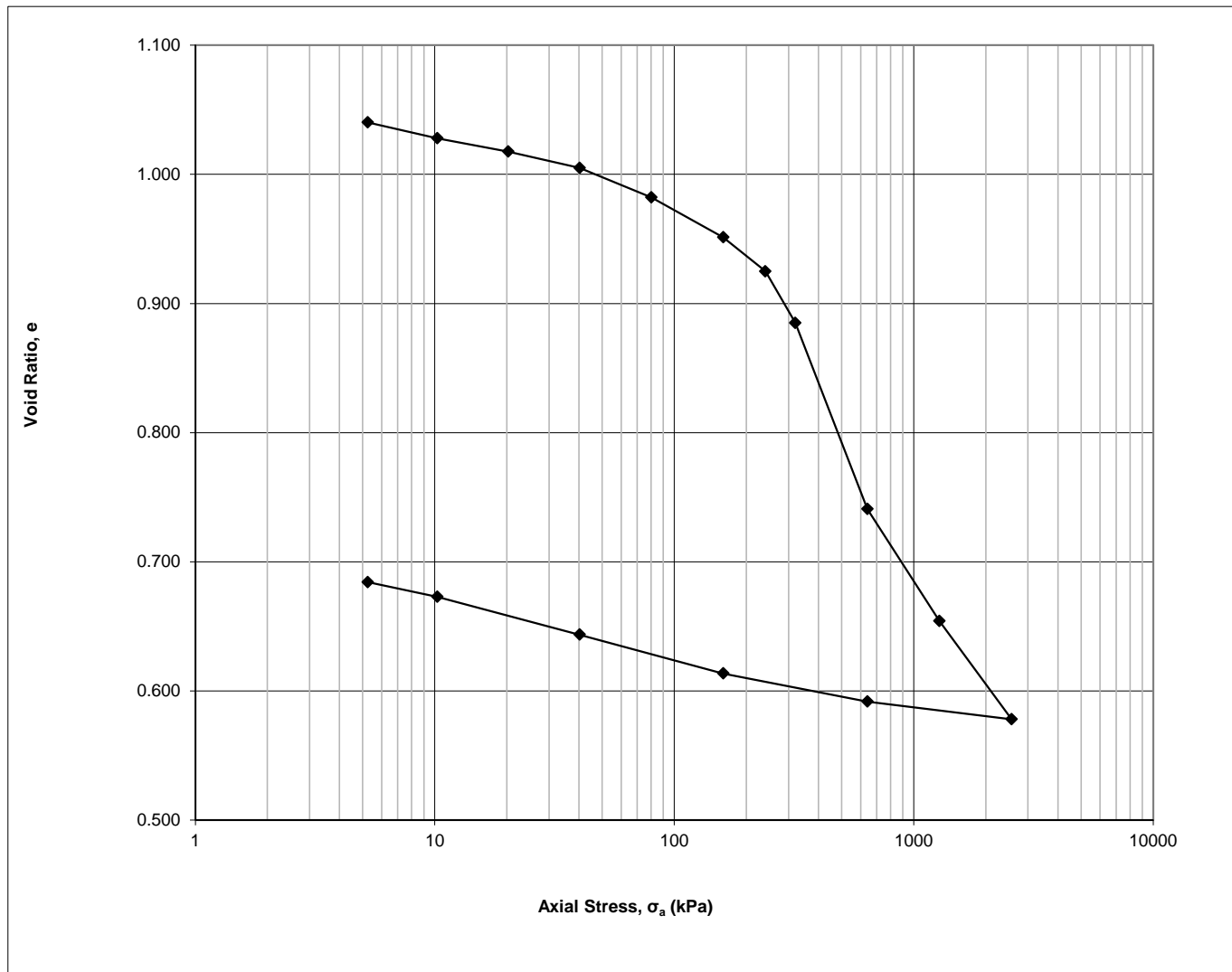


Prep'dSBP.....

Chkd.FJG.....

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File#19-5161-208
122410864
BH 16-4
ST 18
70-72 ft



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File#19-5161-208
Project Location	Calamity Creek
Borehole	BH 16-4
Sample No.	ST 18
Depth	70-72 ft
Sample Date	August 9, 2016
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

CI	
Specific Gravity of Solids	2.708
Liquid Limit %	36
Plastic Limit %	20
Plasticity Index %	16
Average water content of trimmings %	34
Additional Notes (information source, occurrence and size of large isolated particles etc.)	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	69.31
Dry Mass	g	51.86
Density	Mg/m ³	1.765
Dry Density	Mg/m ³	1.321
Water Content	%	33.65
Degree of Saturation	%	86.7
Height of Solids	mm	9.75
Initial Void Ratio		1.051

Final Specimen Conditions

Water Content	%	30.77
Final Void Ratio		0.684

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File#19-5161-208
Project Location	Calamity Creek
Borehole	BH 16-4
Sample No.	ST 18
Depth	70-72 ft
Sample Date	August 9, 2016
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	August 29, 2016
Date Finished	September 13, 2016
Machine Number	Frame D
Cell Number	D
Ring Number	D
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation kPa	5
Water Used	Distilled
Test Method	A
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

--

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ϵ_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.051
1	1440.0	5	0.0999	19.9001	0.50	1.040
2	1440.0	10	0.2202	19.7798	1.10	1.028
3	1440.0	20	0.3207	19.6793	1.60	1.018
4	1440.0	40	0.4449	19.5551	2.22	1.005
5	1440.0	80	0.6670	19.3330	3.34	0.982
6	1440.0	160	0.9691	19.0309	4.85	0.951
7	1440.0	240	1.2251	18.7749	6.13	0.925
8	1440.0	320	1.6150	18.3850	8.08	0.885
9	1440.0	640	3.0211	16.9789	15.11	0.741
10	1440.0	1280	3.8675	16.1325	19.34	0.654
11	1440.0	2560	4.6097	15.3903	23.05	0.578
12	1440.0	640	4.4757	15.5243	22.38	0.592
13	1440.0	160	4.2635	15.7365	21.32	0.613
14	1440.0	40	3.9703	16.0297	19.85	0.644
15	1440.0	10	3.6846	16.3154	18.42	0.673
16	1440.0	5	3.5743	16.4257	17.87	0.684

One-Dimensional Consolidation Test using Incremental Loading

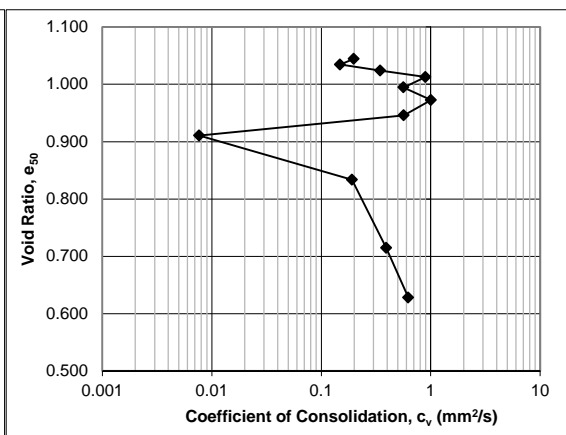
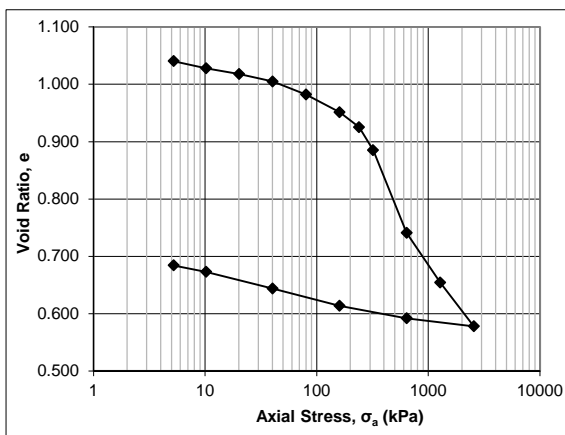
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File#19-5161-208
Project Location	Calamity Creek
Borehole	BH 16-4
Sample No.	ST 18
Depth	70-72 ft
Sample Date	August 9, 2016
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress σ_a , average kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	3								
1	5	0.0605	19.9395	0.30	1.044			426	1.98E-01
2	8	0.1564	19.8436	0.78	1.035			562	1.48E-01
3	15	0.2589	19.7411	1.29	1.024			239	3.46E-01
4	30	0.3689	19.6311	1.84	1.013			91	8.96E-01
5	60	0.5454	19.4546	2.73	0.995			142	5.64E-01
6	120	0.7630	19.2370	3.81	0.972			78	1.01E+00
7	200	1.0224	18.9776	5.11	0.946			135	5.67E-01
8	280	1.3641	18.6359	6.82	0.911			9582	7.68E-03
9	480	2.1178	17.8822	10.59	0.833			355	1.91E-01
10	960	3.2764	16.7236	16.38	0.715			151	3.92E-01
11	1920	4.1215	15.8785	20.61	0.628			86	6.24E-01
12	1600	4.5023	15.4977	22.51	0.589				
13	400	4.3396	15.6604	21.70	0.606				
14	100	4.0894	15.9106	20.45	0.631				
15	25	3.9543	16.0457	19.77	0.645				
16	8	3.6813	16.3187	18.41	0.673				



Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Stephen Peters

Client PO: 19-5161-208
Project: Calamity Creek
Custody: 27364

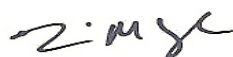
Report Date: 29-Aug-2016
Order Date: 24-Aug-2016

Order #: 1635297

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1635297-01	16-1, SS3, 5'-7'
1635297-02	16-4, SS16, 60'-62'
1635297-03	16-6, SS3, 5'-7'

Approved By:



Tim McCooeye
Senior Advisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	29-Aug-16	29-Aug-16
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	25-Aug-16	25-Aug-16
Resistivity	EPA 120.1 - probe, water extraction	26-Aug-16	26-Aug-16
Solids, %	Gravimetric, calculation	25-Aug-16	25-Aug-16

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Client ID:	16-1, SS3, 5'-7'	16-4, SS16, 60'-62'	16-6, SS3, 5'-7'	-
Sample Date:	11-Aug-16	09-Aug-16	14-Aug-16	-
Sample ID:	1635297-01	1635297-02	1635297-03	-
MDL/Units	Soil	Soil	Soil	-

Physical Characteristics

% Solids	0.1 % by Wt.	71.6	70.9	65.2	-
----------	--------------	------	------	------	---

General Inorganics

pH	0.05 pH Units	8.05	8.06	7.92	-
Resistivity	0.10 Ohm.m	52.3	52.2	56.8	-

Anions

Chloride	5 ug/g dry	20	8	17	-
Sulphate	5 ug/g dry	24	32	28	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	135	5	ug/g dry	134			0.2	20	
Sulphate	517	5	ug/g dry	494			4.4	20	
General Inorganics									
pH	8.08	0.05	pH Units	8.05			0.4	10	
Resistivity	52.2	0.10	Ohm.m	52.2			0.2	20	
Physical Characteristics									
% Solids	83.6	0.1	% by Wt.	82.1			1.8	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	240	5	ug/g	134	106	78-113			
Sulphate	588	5	ug/g	494	93.6	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 19-5161-208

Report Date: 29-Aug-2016

Order Date: 24-Aug-2016

Project Description: Calamity Creek

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

RECORD OF BOREHOLE No DB3

1 OF 2

METRIC

W.P. WP147-98-00 LOCATION Hwy 11 Dymond Twp Stn 17+630 O/S 3.1 m Rt. ORIGINATED BY T.B
 DIST Northern HWY Hwy 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T
 DATUM _____ DATE 10.05.99 & 10.05.99 CHECKED BY P.M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
0.0	Ground Surface																
0.2	220 mm Asphalt																
0.3	50 mm Sand and gravel, brown, moist																
0.4	70 mm Asphalt																
0.6	170 mm Sand and gravel																
0.7	70 mm Asphalt, over Sand and gravel			SPT		19											
	FILL: clayey silt with trace organics and some gravel sizes, grey, moist, very stiff, over (possible fill) grey, moist clayey silt with trace organics 25 mm thick layer of topsoil			SPT		32											
				SPT		20											
6.3	SILTY CLAY: greenish, moist, stiff very soft			SPT		6											
				SPT		11											
				SPT		21											
				SPT		19											
				SPT		10											
	with layers of organics becoming brown, very stiff fissured, stiff becoming wet at 10.7 m			SPT		7											
11.5	VARVED CLAY: rhythmic layers of dark grey silty clay to clay and light grey clayey silt to silt.			SPT		3											
				SPT		4											
				SHELBY													
				SPT		5											

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No DB3

2 OF 2

METRIC

W.P. WP147-98-00 LOCATION Hwy 11 Dymond Twp Stn 17 + 630 O/S 3.1 m Rt. ORIGINATED BY T.B
 DIST Northern HWY Hwy 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T
 DATUM DATE 10.05.99 & 10.05.99 CHECKED BY P.M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100					
								○ UNCONFINED	+	FIELD VANE							
								● QUICK TRIAXIAL	×	LAB VANE							
								20	40	60	80	100	20	40	60		
										</							

+ 3, × 3: Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE

RECORD OF BOREHOLE No DB4

1 OF 2

METRIC

W.P. WP147-98-00 LOCATION Hwy 11 Dymond Twp Stn 17+679 O/S 2.9 m Lt. ORIGINATED BY T.B
 DIST Northern HWY Hwy 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T
 DATUM _____ DATE 10.05.99 & 10.05.99 CHECKED BY P.M

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
0.0	Ground Surface															
0.2	195 mm Asphalt															
	FILL: sand and gravel, moist			SPT	27											
				SPT	11											
				SPT	27											
	with trace clay			SPT	10											
				SPT	8											
9.1	CLAYEY SILT: with some sand and gravel, brown			SPT	15											
	with some organics															
10.6	CLAYEY SILT: with some gravel and organics, brown, moist			SPT	14											
				SPT	20											
12.8	SILTY CLAY: grey, organics			SPT	27											
				SPT	19											
	becoming brown with trace			SPT	9											

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No DB4

2 OF 2

METRIC

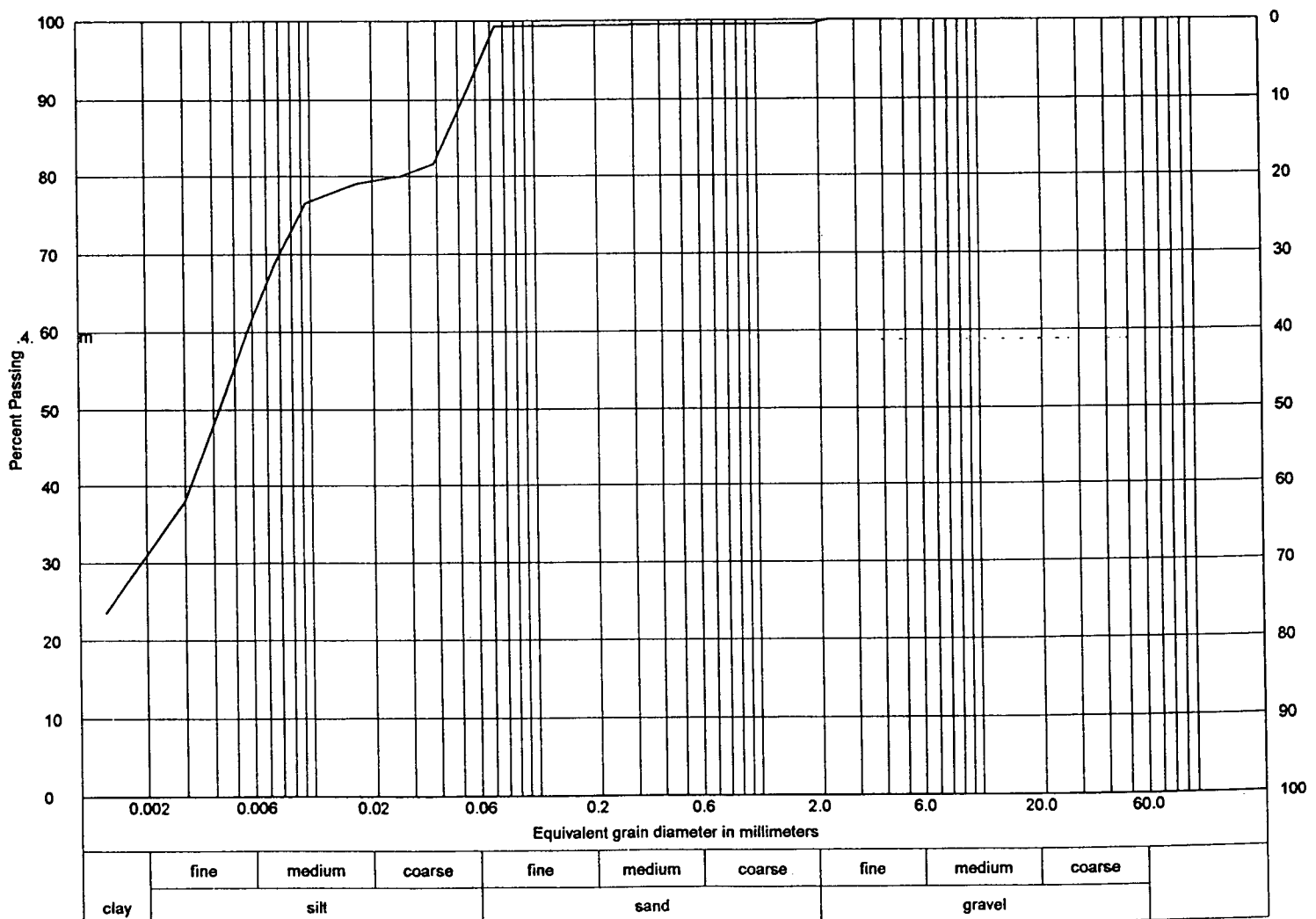
W.P. WP147-98-00 LOCATION Hwy 11 Dymond Twp Stn 17 + 679 O/S 2.9 m Lt. ORIGINATED BY T.B
 DIST Northern HWY Hwy 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T
 DATUM _____ DATE 10.05.99 & 10.05.99 CHECKED BY P.M

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W P	W			W L
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
							20 40 60 80 100					20 40 60					
14.8	organics VARVED CLAY: rhythmic layers of dark grey silty clay to clay and light grey clayey silt to silt. <																

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE

SAMPLE NUMBER: 2946/5
PROJECT NUMBER: SP3012
PROJECT: New Liskard
CONTRACT:
CLIENT: Ministry of Transportation
CONTRACTOR:
PROJECT MANAGER:
PROJECT SITE:
SAMPLED BY: T. Bhatti
DATE SAMPLED: 9/30/99
SUPPLIER:
SAMPLE LOCATION: DB# 3 SB-4 (16.77-17.23m)
DESCRIPTION: Clay and silt, trace sand
PROPOSED USE:
DATE TESTED: 11/21/99
SPECIFICATION: Hydrometer

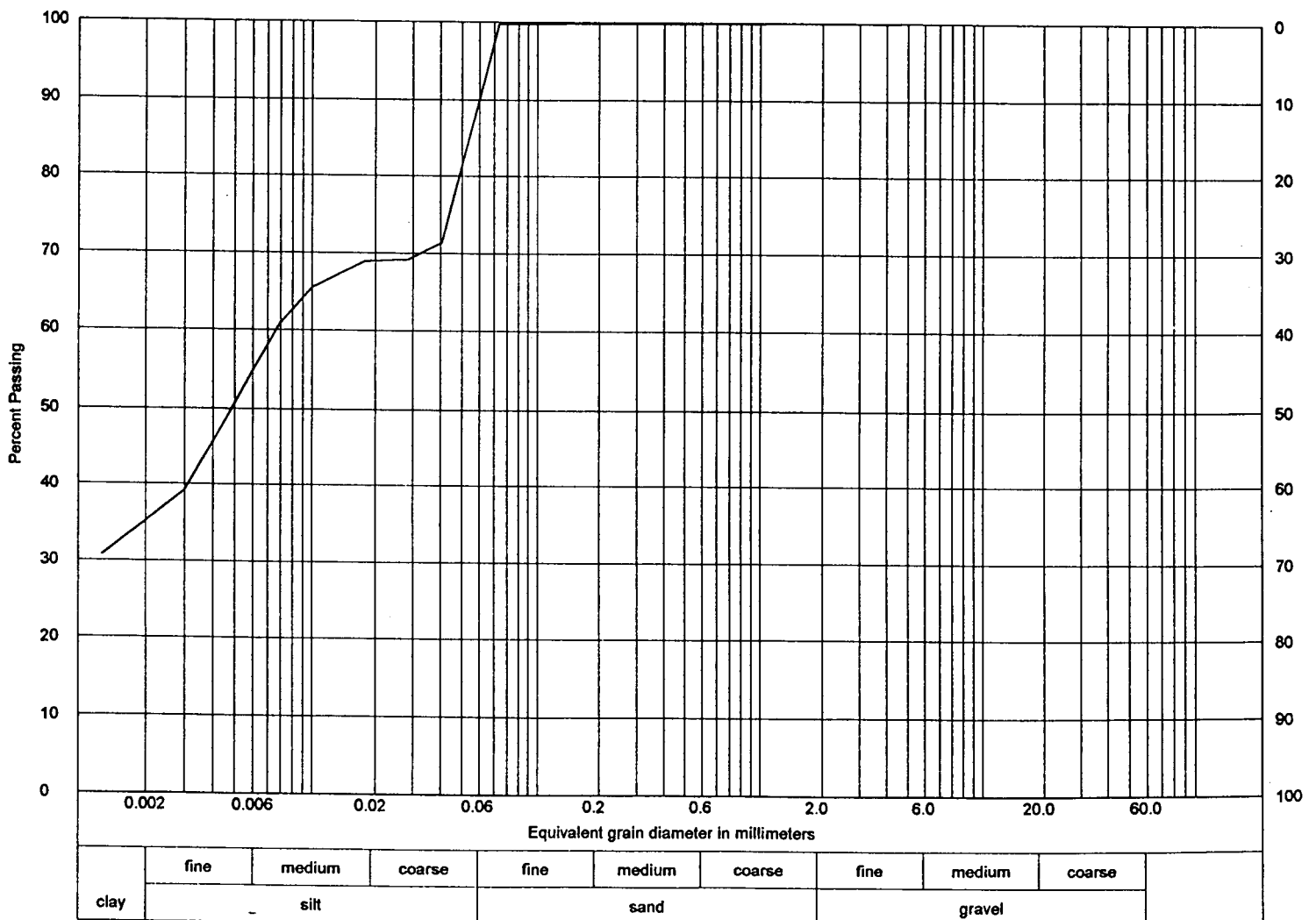
SIEVE SIZE	PERCENT PASSING	SPECIFICATION
19.0 mm	100.0	
16.0 mm	100.0	
13.2 mm	100.0	
9.5 mm	100.0	
4.75 mm	100.0	
2.36 mm	100.0	
2.00 mm	99.5	
1.18 mm	99.5	
600 mic	99.5	
300 mic	99.4	
150 mic	99.4	
75 mic	99.3	



COMMENTS

SAMPLE NUMBER: 2946/6
 PROJECT NUMBER: SP3012
 PROJECT: New Liskard
 CONTRACT:
 CLIENT: Ministry of Transportation
 CONTRACTOR:
 PROJECT MANAGER:
 PROJECT SITE:
 SAMPLED BY: T. Bhatti
 DATE SAMPLED: 9/30/99
 SUPPLIER:
 SAMPLE LOCATION: DB# 3 SB-6 (23.18-23.64m)
 DESCRIPTION: Clay and silt, trace sand
 PROPOSED USE:
 DATE TESTED: 11/21/99
 SPECIFICATION: Hydrometer

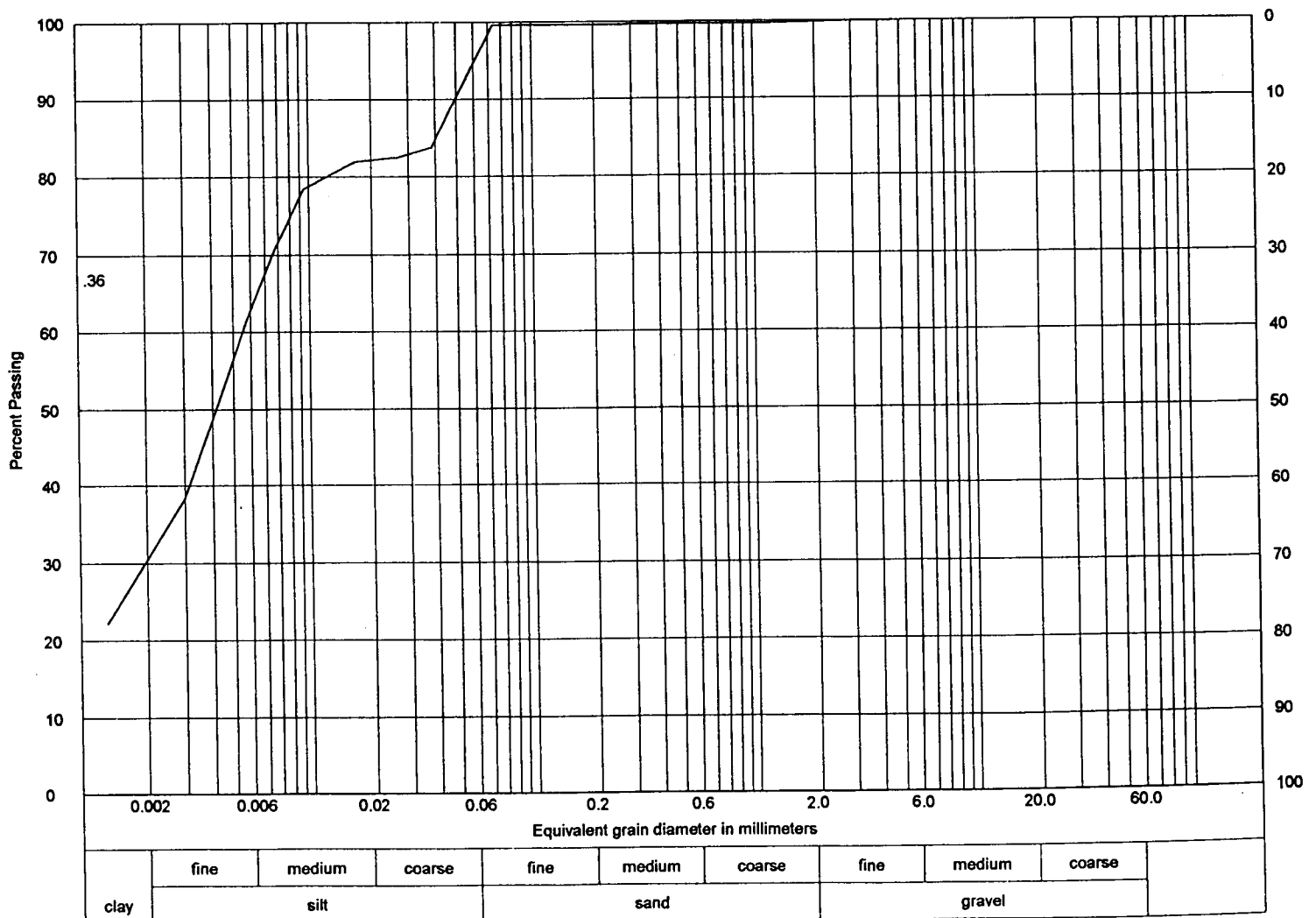
SIEVE SIZE	PERCENT PASSING	SPECIFICATION
19.0 mm	100.0	
16.0 mm	100.0	
13.2 mm	100.0	
9.5 mm	100.0	
4.75 mm	100.0	
2.36 mm	100.0	
2.00 mm	100.0	
1.18 mm	99.9	
600 mic	99.9	
300 mic	99.8	
150 mic	99.8	
75 mic	99.7	



COMMENTS

SAMPLE NUMBER: 2946/7
 PROJECT NUMBER: SP3012
 PROJECT: New Liskard
 CONTRACT:
 CLIENT: Ministry of Transportation
 CONTRACTOR:
 PROJECT MANAGER:
 PROJECT SITE:
 SAMPLED BY: T. Bhatti
 DATE SAMPLED: 8/31/99
 SUPPLIER:
 SAMPLE LOCATION: DB# 4 SB-4 (20.58-21.04m)
 DESCRIPTION: Clayey silt, trace sand
 PROPOSED USE:
 DATE TESTED: 11/21/99
 SPECIFICATION: Hydrometer

SIEVE SIZE	PERCENT PASSING	SPECIFICATION
19.0 mm	100.0	
16.0 mm	100.0	
13.2 mm	100.0	
9.5 mm	100.0	
4.75 mm	100.0	
2.36 mm	99.8	
2.00 mm	99.8	
1.18 mm	99.7	
600 mic	99.7	
300 mic	99.6	
150 mic	99.6	
75 mic	99.6	



COMMENTS



Appendix G.

Previous Slope Monitoring by Others

Slope Failure – South West side (Outlet Side) – Brief Update

A- On Monday, the 9th of the November 2020 (7:00 am)

the CA team noted a slope failure on the South West Side of outlet of the new constructed Culverts.



Figure 1: Prior Slope Failure



Figure 2: After Slope Failure

The CA notified the spill center (MECP) regarding a slope failure that caused a partial “pinching” of the Creek. The CA informed the center that only earth material that partially entered the narrow stream of

water. It was noted to the center that no wildlife was affected by the slope failure. Report reference is 1243-BV7MU6

The CA Notified CSA regarding the matter via text and attached ground pictures from site then areal pictures was made available (Areal Pictures are courtesy of CDB).

B- On Tuesday, the 10th of November 2020 (1:00 am)

The CA team installed survey stakes to barricade and monitor the area of the failure. The stakes were placed where visual tension cracks in ground were observed. Those tension cracks some of them are new and some are years old. During the installation of the stakes it was suspected that a new tension crack was developed at the top of the slope. The area was marked to confirm if the tension crack is evolving. It should be noted that the area is vegetated with tall grass which hid any progression of the failure which created an access hazard.

The CA team hired the service the fisheries specialist and a biologist to conduct an assessment on site. The specialists were on site around 1:00 pm.



Figure 3: Top of the Slope Facing Southerly

The fisheries specialists including the biologist took measurement around the area and pictures and will issue a report.

The CA team noted that water from the culvert outlets are still draining at a low rate as the new stream is taking shape. The slow movement of water through the stream made the pond at the outlet wider (Figure 1 when compared to figure 2).



Figure 4: Top View of the Stream on Tuesday – 10 November 2020



Figure 5: Stream Condition on Tuesday facing Northerly- 10 November 2020

C- On Wednesday, the 11th of November 2020 (11:14 am)

At 11:14 am, due to slow drainage of at the outlet, the water elevation at the NW outlet culvert was 195.05 while the invert of the outlet pipe is 194.15 (0.900 m of water)

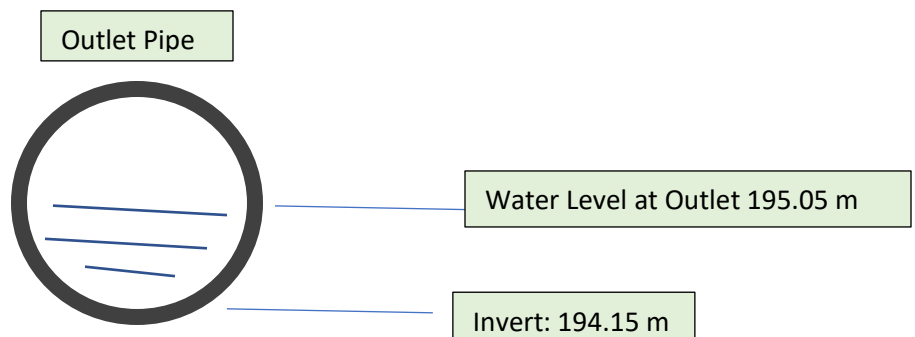




Figure 6: Top of Slope failed further – Facing Southerly



Figure 7: Top of Slope facing Northerly

The CA team noted that the tension crack noted on Tuesday caved in further when compared with Figure 3. As you can see, the MTO Marker is part of the failed slope now.

D- On Thursday, the 12th of November 2020 (10:00 am)



The CA team noted that a new tension crack hidden under the tall grass at the top of the failed slope was discovered today in the path that the CA used for the last 2 days as it was deemed safe then.

It should be noted that there was no further failure at the bottom of the failed slope and there were no changes to the stream condition since Monday with exception of the water is creating a new path.

E- On Friday, the 13th of November 2020 (9:00 am)

We conducted our daily survey for today. We did not note any changes from yesterday. However, in the case it will rain, the situation is most likely to change. Water level has receded to an elevation to (194.80) making a difference of .250mm since Wednesday 11 Nov 2020.



Figure 8: Top of Slope Failure on Friday 13th of Nov 2020 - No Changes from Wednesday 11th of Nov 2020

F- On Monday, the 16th of November 2020 (09:00 am)

We conducted inspection this morning at approximately 9:00am. It was noted that there were no changes to the channel based on visual observations. The water elevation has increased slightly due to the rain activities during the weekend. The water elevation recorded at the outlet is 194.822 m.

It has been observed (2) movement of the upper portion of the south slope:

- 1- Since Friday, the failed upper portion of the slope has shown further movement by losing more ground (see figure 10) and more tension crack appeared when compared to last Friday Nov 13th, 2020.
- 2- A new additional tension cracks has been observed East of the original noted failure (See Figure 9).

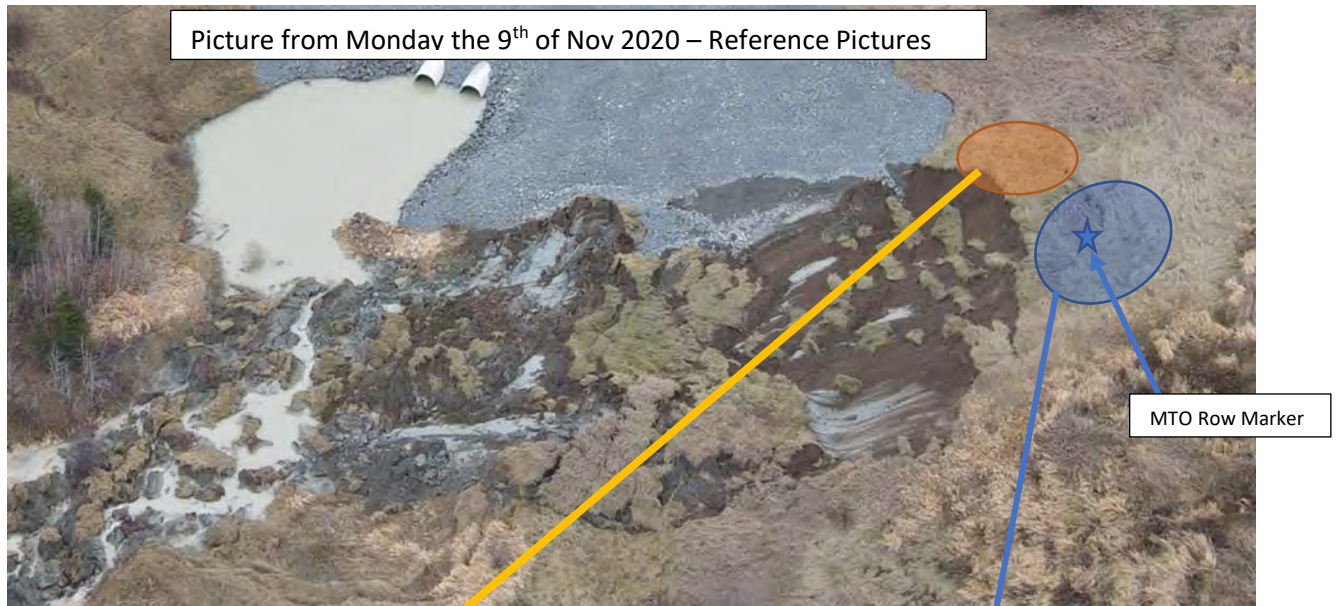


Figure 10: Top of Failed Slope Facing Easterly – 16th Nov 2020



Figure 9: Top of Failed Slope Facing Southerly – 16th of Nov 2020

G- On Tuesday, the 17th of November 2020 (08:45am)

We conducted inspection this morning at approximately 08:45 am. It was noted that there were no changes to the channel based on visual observations. The water elevation at the North pipe outlet is at 194.750 m (yesterday elevation was 194.822 m)

Today observations noted that both areas show signs of further movement.



H- On Wednesday, the 18th of November 2020 (09:15am)

It has been observed that there are no changes to the condition of the downstream channel as for any further blocking. The plunge pool has begun to freeze due to the colder weather. The water elevation at the outlet pipe this morning at 9:15 is sitting at (194.720m) slight drop in comparison to yesterday's record

- 1- Evolution the **Blue Marked Area**: More movement were noted today when compared to yesterday pictures.



- 2- Evolution the **Orange Marked Area**: More movement were noted today when compared to yesterday pictures. The tension crack that developed between the failed slope and the rock protected area is increasing in width and length. We added (2) additional survey stakes adjacent to the ground tension cracked noted yesterday.



I- On Thursday, the 19th of November 2020 (09:15am)

From observation at 8:20am this morning the creek channel shows no changes. Water elevation measurement at the outlet pile was(194.700 m) which is slightly lower than yesterday water level. It does not appear that the upper portion of the south slope has moved. However, the newest tension crack that developed this week (Marked in Orange) shows a sign of movement.

Please be advised that the Inspector met with the private landowner this morning and provided him with the contact information of the CSA for future communication.



J- On Friday, the 20th of November 2020 (08:30am)

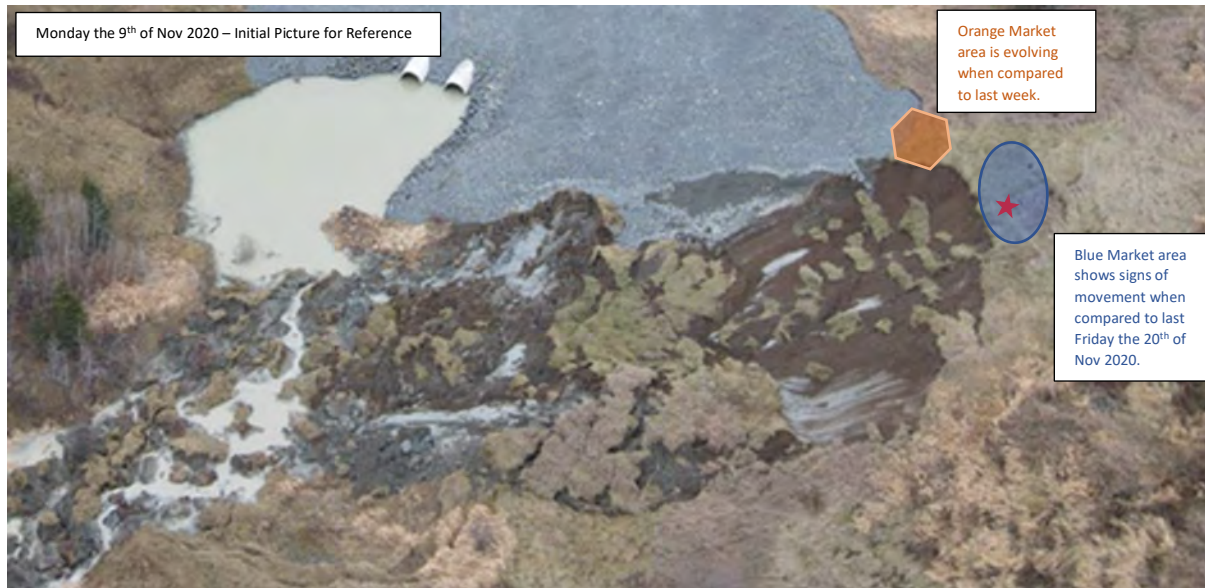
Inspection was performed at 8:30 this morning and there were no apparent changes to the downstream creek channel. Water elevation recorded at (194.690) slight decrease to yesterday's elevation.

The upper portion appears to show no sign of movement. On the other hand, the recent tension crack that developed this week has showed signs of movement (Marked in Orange). Survey stake that was placed earlier this Wednesday (18th of Nov 2020) commenced to shift – See picture below.



K- On Wednesday, the 25th of November 2020 (12:35 pm)

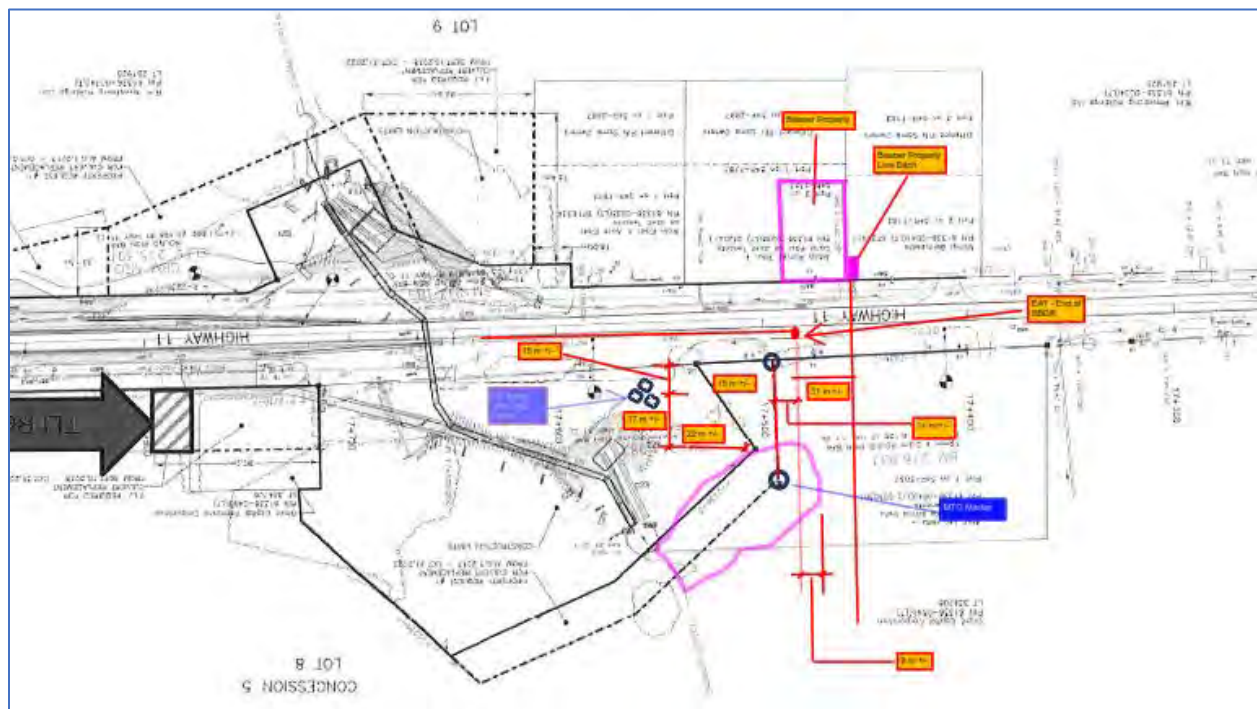
Based on today site visit, the Inspector identified that the upper portion of the south slope (Blues marked area) shows signs of movement. The secondary location (Orange marked area) that was developed last week has shown signs of further movement. There have been additional tension cracks more easterly. Inspector Installed new reference survey stakes to monitor them.





L- On Thursday, the 26th of November 2020

The CA team conducted a site measurement to markup the limits of the slope failure on the TLI documents.



M- On Monday, the 30th of November 2020

The CA Team conducted slope failure monitoring this morning. It was determined that there were no changes to the downstream creek channel. Furthermore, it was confirmed that there were no additional tension cracks on the upper portion of the south slope. However, it was noted that the top of the (2) areas (East and West of the South slope – Blue and Orange marked areas) has moved further when compared to last week.

a- West of South Slope (Blue Marked Area)



b- East of South Slope (Orange Marked Area)



N- On Wednesday, the 2nd of December 2020

Monitoring of the south slope failure this morning at 8:30 showed no signs of change for the downstream creek channel. There is movement noted on the east side of the upper section of the slope failure. From observation it would appear there are no additional tension cracks at the upper portion of the south slope failure at this time. (See Attached Pictures)

O- On Friday, the 4th of December 2020

Monitoring took place at 8:00 am this morning and no changes to the condition to the downstream channel. From observation at the upper portion tension crack that is on the East side shows sign of some movement. There were no visible additional tension cracks above the upper portion of the slope failure. (See Attached Pictures)

P- On Monday, the 7th of December 2020

Monitoring has taken place at 8:45 this morning. From observations there are no changes to the creek channel or the upper portion of the south slope (East or West side of the upper portion).

Note:

- It has been observed monitoring survey points have been erected. (see attached pictures).

Q- On Wednesday, the 9th of December 2020

Monitoring has taken place at 12:40pm today. From observations there are no signs of changes to the downstream creek channel. On the upper portion, more Easterly, an additional tension crack has been observed at the second survey stake. The stake was placed at a predetermined location (Where a small Crack in the ground is detected). It has been confirmed that the area where stake #2 is located begun to show signs of movement.



R- On Friday, the 11th of December 2020

Site monitoring was conducted this morning. It was noted that the downstream creek channel shows no changes. On the upper portion of the failed slope, the latest tension crack shows signs of further movement.



S- On Monday, the 14th of December 2020

Site monitoring was conducted this morning. The upper portion of the failed slope and the latest tension crack shows no signs of movement when compared to last week.



It was noted that the downstream creek channel shows no changes with exception of snow accumulations.



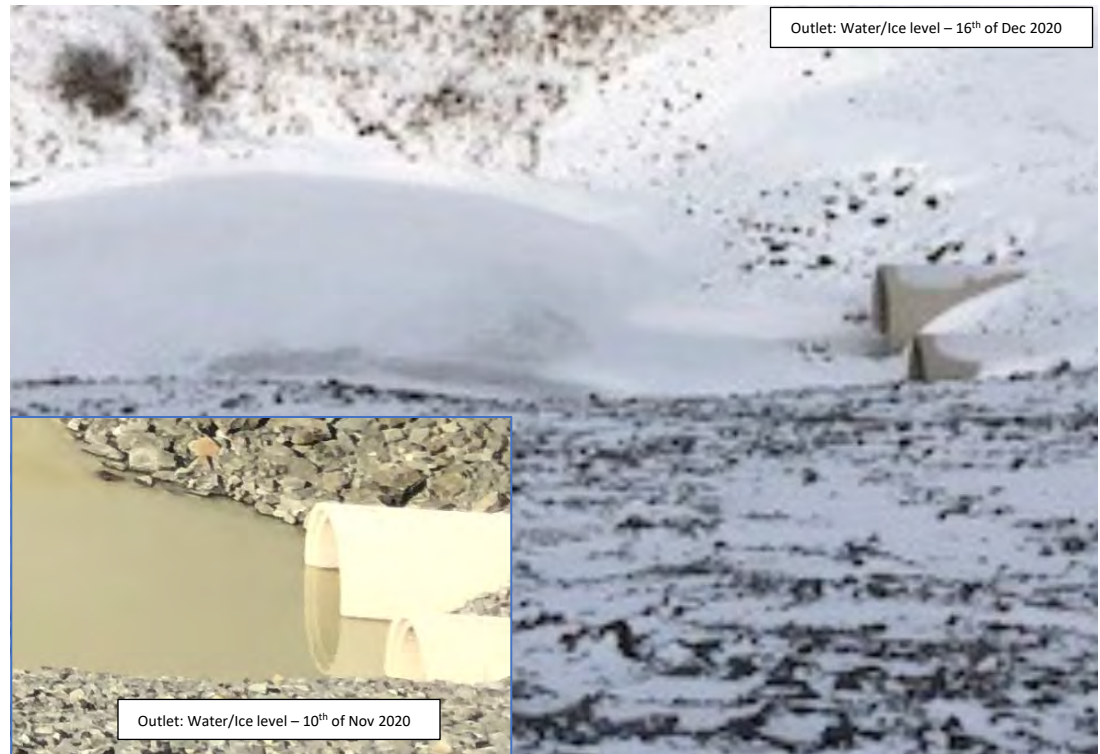
T- On Wednesday, the 16th of December 2020

Site monitoring was conducted this morning. There were 4-8 inch of snow on the ground. The upper portion of the failed slope and the latest tension crack shows no signs of movement when compared to Monday the 14th of Dec 2020. For instance, the survey stakes (Placed by the CA team) did not show any signs of movement.

Note: Survey Stakes were placed exactly where a tension crack were detected.



It was noted that the downstream creek channel shows no changes with exception of snow accumulations. The ice level at the culvert outlets is below the level registered on the 10th of Nov 2020.



U- On Friday, the 18th of December 2020

Site monitoring was conducted this morning. The upper portion of the failed slope and the latest tension crack shows no signs of movement when compared to Wednesday the 16th of Dec 2020. However, it was noted that at the top of the slope face, there were accumulation of soil on top of the snow on the ground that was not noted last Wednesday (16th Dec 2020). It is in the CA opinion that the wind blew around soil particles on top of the snow on the ground and it is not a sign of any movement. .





Appendix H.

GSC Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 47.554N 79.673W

User File Reference: Calamity Creek

2021-12-07 13:59 UT

Requested by: Thurber Engineering Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.179	0.101	0.060	0.016
Sa (0.1)	0.227	0.134	0.083	0.024
Sa (0.2)	0.201	0.121	0.076	0.024
Sa (0.3)	0.159	0.097	0.062	0.021
Sa (0.5)	0.118	0.072	0.046	0.016
Sa (1.0)	0.063	0.039	0.025	0.008
Sa (2.0)	0.031	0.019	0.012	0.003
Sa (5.0)	0.008	0.004	0.003	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.126	0.074	0.045	0.013
PGV (m/s)	0.096	0.055	0.034	0.010

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Appendix I.

Comparison of Design Alternatives



Table I: Comparison of Slope Remediation Options

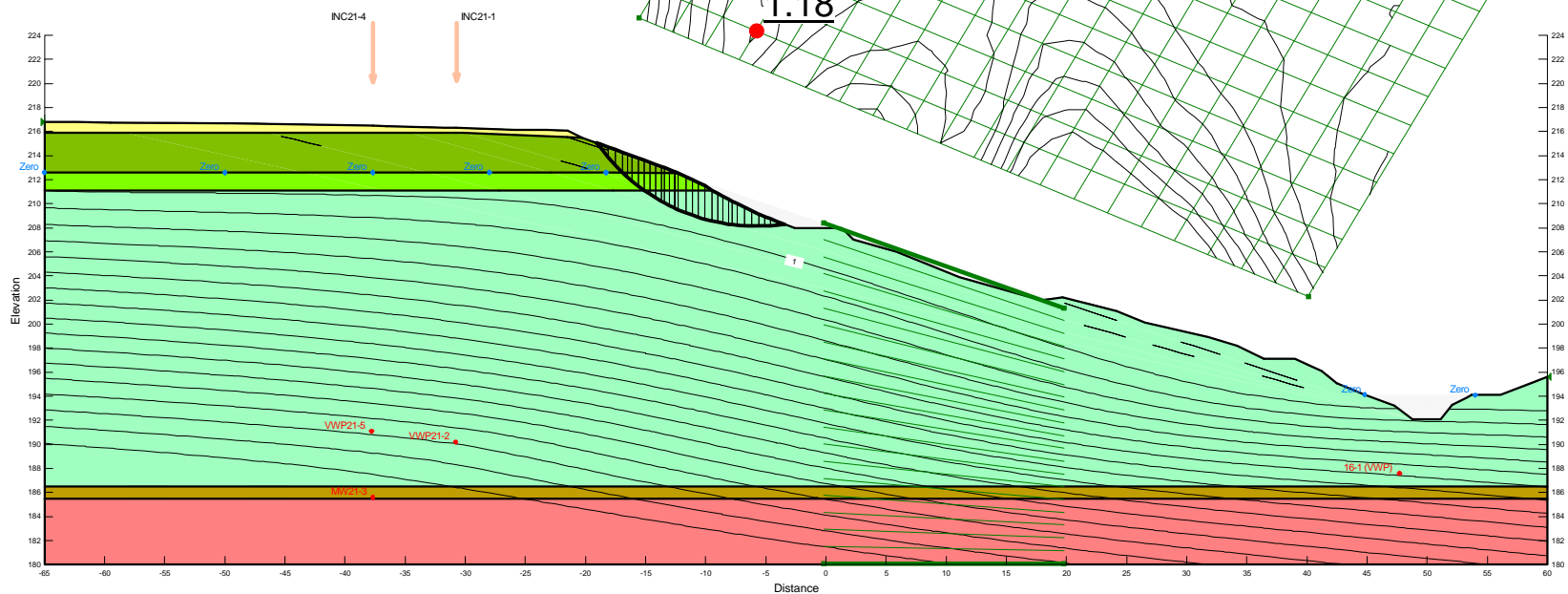
	1) Do Nothing	2) Flatten The Slope	3) Add Rip Rap Buttress to Infill Creek Valley
Advantages	<ul style="list-style-type: none"> • Lowest cost • Least likely to result in additional failures downstream 	<ul style="list-style-type: none"> • The factor of safety against slope instability is improved to ~1.3 for slopes as flat as 3.5H:1V. • Relatively simple construction from the tableland only. Minimal site preparation is required. 	<ul style="list-style-type: none"> • The factor of safety against slope instability is improved to ~ 1.3. • Future erosion of the toe-of-slope will be limited and therefore the risk of a large global slope failure is lowest with this option, especially if combined with Option 2.
Disadvantages	<ul style="list-style-type: none"> • The factor of safety against slope instability is not improved. Future retrogressive failures are likely. • The potential for erosion of the toe at the creek level is not addressed. Future global slope failures are possible due to erosion of the toe-of-slope. • Purchasing and abandoning the house would be required to limit the risk of property damage and loss of life. • Future failures could impact the creek and therefore flow through the culvert. 	<ul style="list-style-type: none"> • The potential for erosion of the toe at the creek level is not addressed. Future global slope failures are possible due to erosion of the toe-of-slope, noting that the potential is reduced by flattening the slope. • Temporary access from the property owners would be required. • The slope flattening will permanently encroach on private property. Purchasing the house may still be required. 	<ul style="list-style-type: none"> • A temporary access road will be required to bring rockfill down to the creek level. • Hydraulic and environmental impacts to the creek will occur. Consultation with experts in the fields will be required.
Recommendation	Feasible with abandonment of the house and future monitoring	Options 2 and 3 should both be implemented if possible. Option 3 is preferred over Option 2 because it addresses erosion of the toe.	



Appendix J.

Slope Stability Figures







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

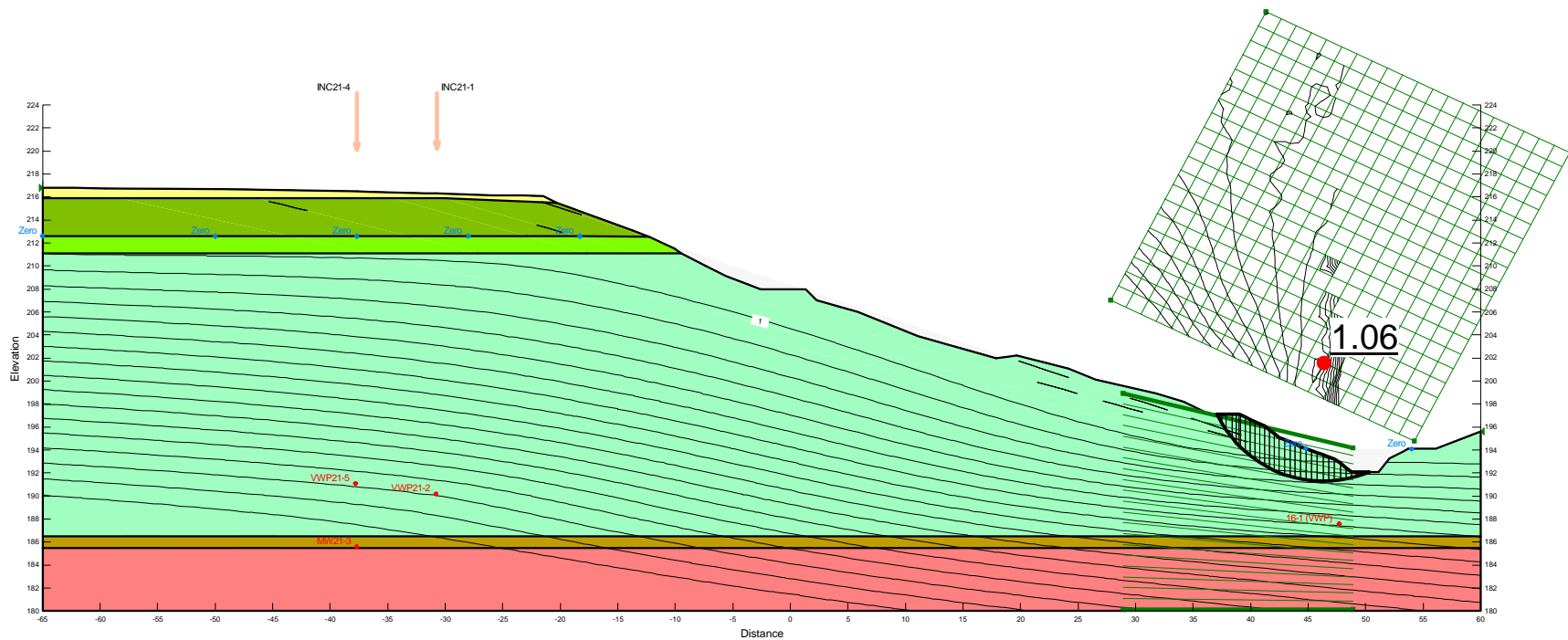


Project Calamity Creek		
Analysis 01) Permanent, static-drained conditions (upper slope only)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:39:40 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-19.060893, 215.04942) m, Exit: (-3.4373404, 208.30702) m
 Center: (-5.7803404, 224.35054) m, Radius: 16.213696 m

Figure J1







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

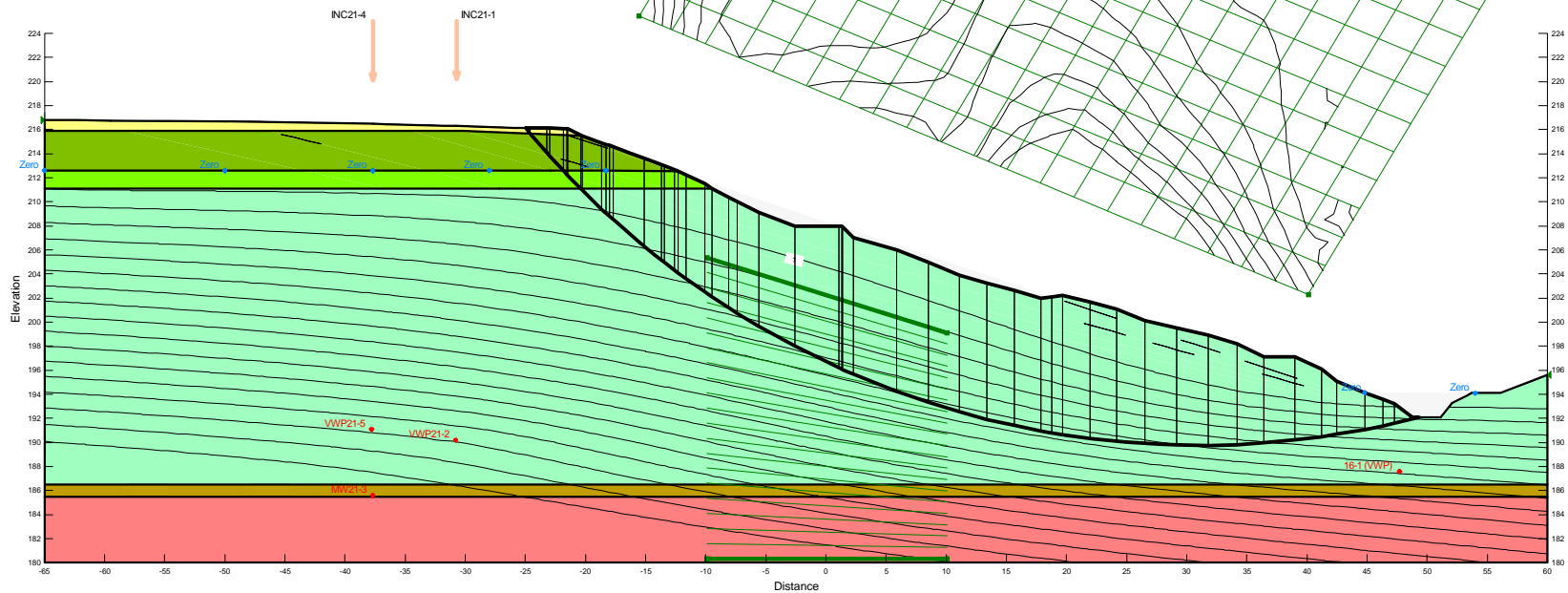


Project Calamity Creek		
Analysis 02) Permanent, static-drained conditions (lower slope only)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:38:09 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (37.08808, 197.1) m, Exit: (50.352671, 192.1) m
 Center: (46.345496, 201.56423) m, Radius: 10.277603 m

Figure J2







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

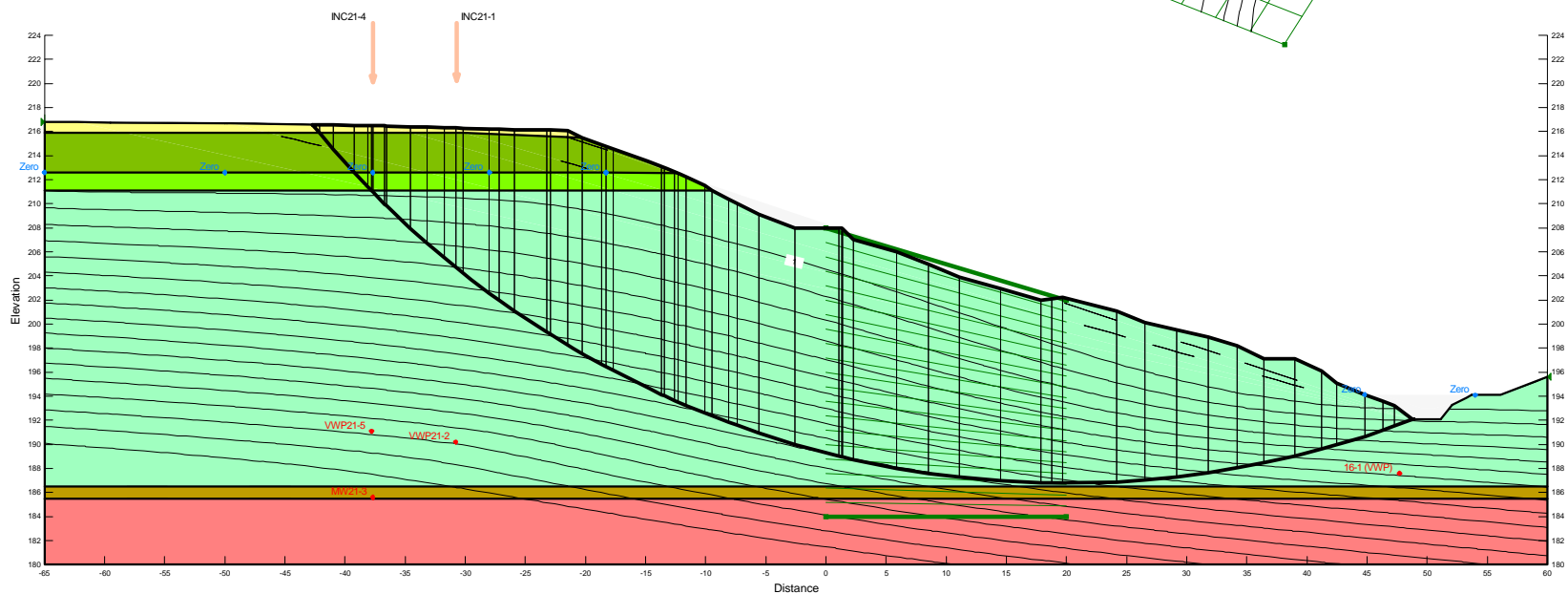


Project		
Calamity Creek		
Analysis		
03) Permanent, static-drained conditions (global slope)		
Seismic Coefficient	Last Run	Scale
H: g, V: g	01/27/2022, 11:38:22 AM	1:60

Additional Details
Name: Section A-A
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 3.05 m
Entry: (-24.987943, 216.13425) m, Exit: (49.289313, 192.1) m
Center: (30.993214, 262.3495) m, Radius: 72.592974 m

Figure J3







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (TSA)	Undrained (Phi=0)	18				80		
	C. Varved CLAY 1 (TSA)	Undrained (Phi=0)	16.5				75		
	D. Varved CLAY 2 (TSA)	S=f(depth)	17.5	40	1.33	75			
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock (Impenetrable)	Bedrock (Impenetrable)							

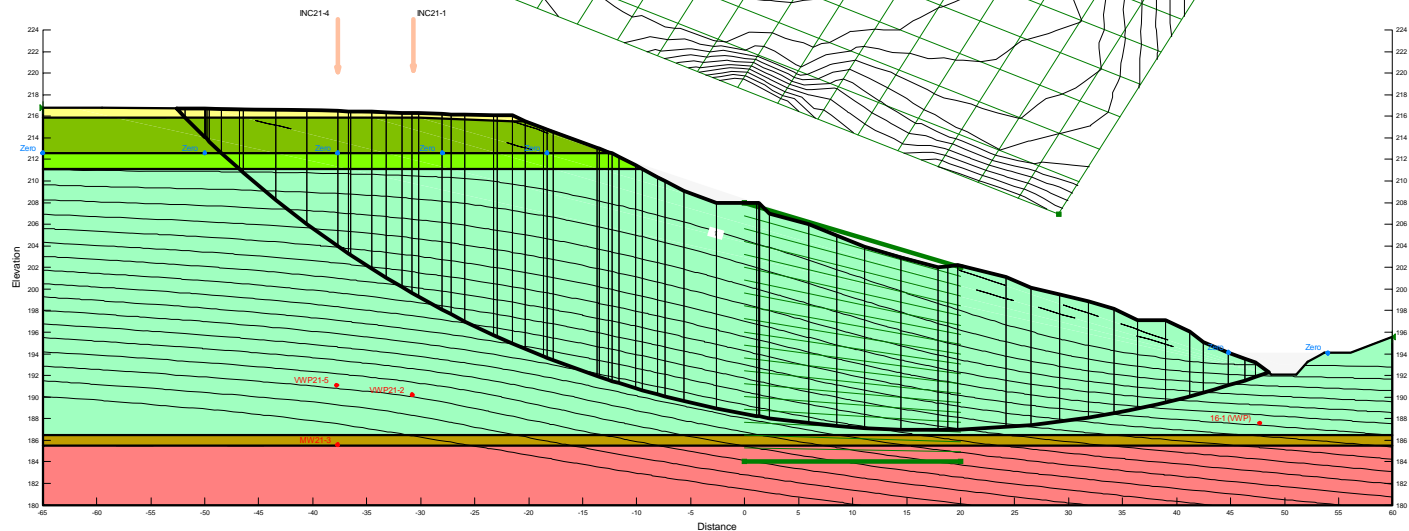


Project Calamity Creek		
Analysis 04) Temporary, static-undrained (global slope)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:37:23 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-42.707601, 216.58143) m, Exit: (48.892475, 192.1) m
 Center: (20.032792, 267.725) m, Radius: 80.944561 m

Figure J4







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m³)/m)	C-Maximum (kPa)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (TSA)	Undrained (Phi=0)	18				80		
	C. Varved CLAY 1 (TSA)	Undrained (Phi=0)	16.5				75		
	D. Varved CLAY 2 (TSA)	S=f(depth)	17.5	40	1.33	75			
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

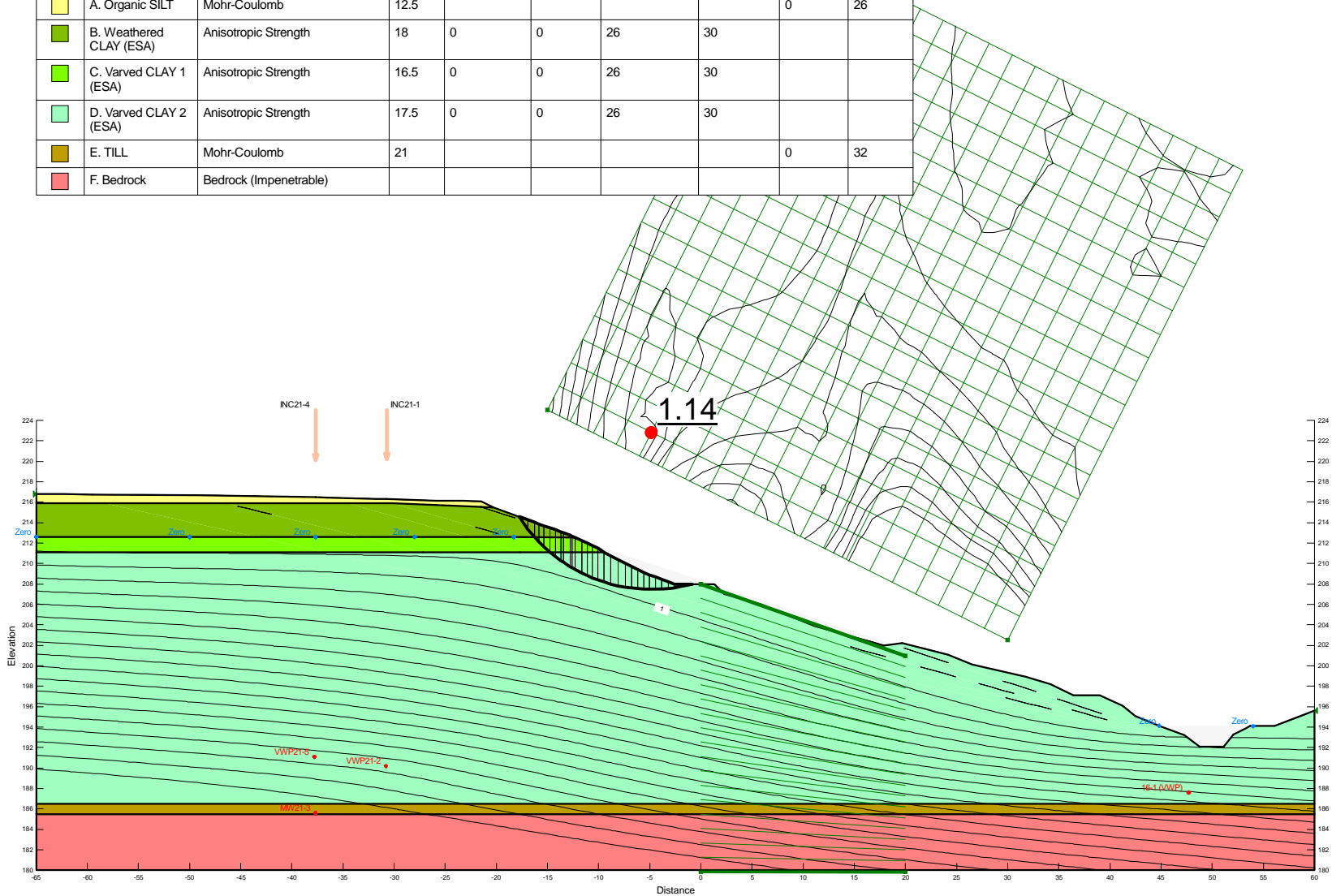


Project Calamity Creek		
Analysis 05) Temporary, static-undrained with 2475 yr earthquake		
Seismic Coefficient H: 0.115g, V: g	Last Run 01/27/2022, 11:38:34 AM	Scale 1:700

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-52.609675, 216.7174) m, Exit: (48.528627, 192.29815) m
 Center: (16.895843, 282.93737) m, Radius: 96.000527 m

Figure J5







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

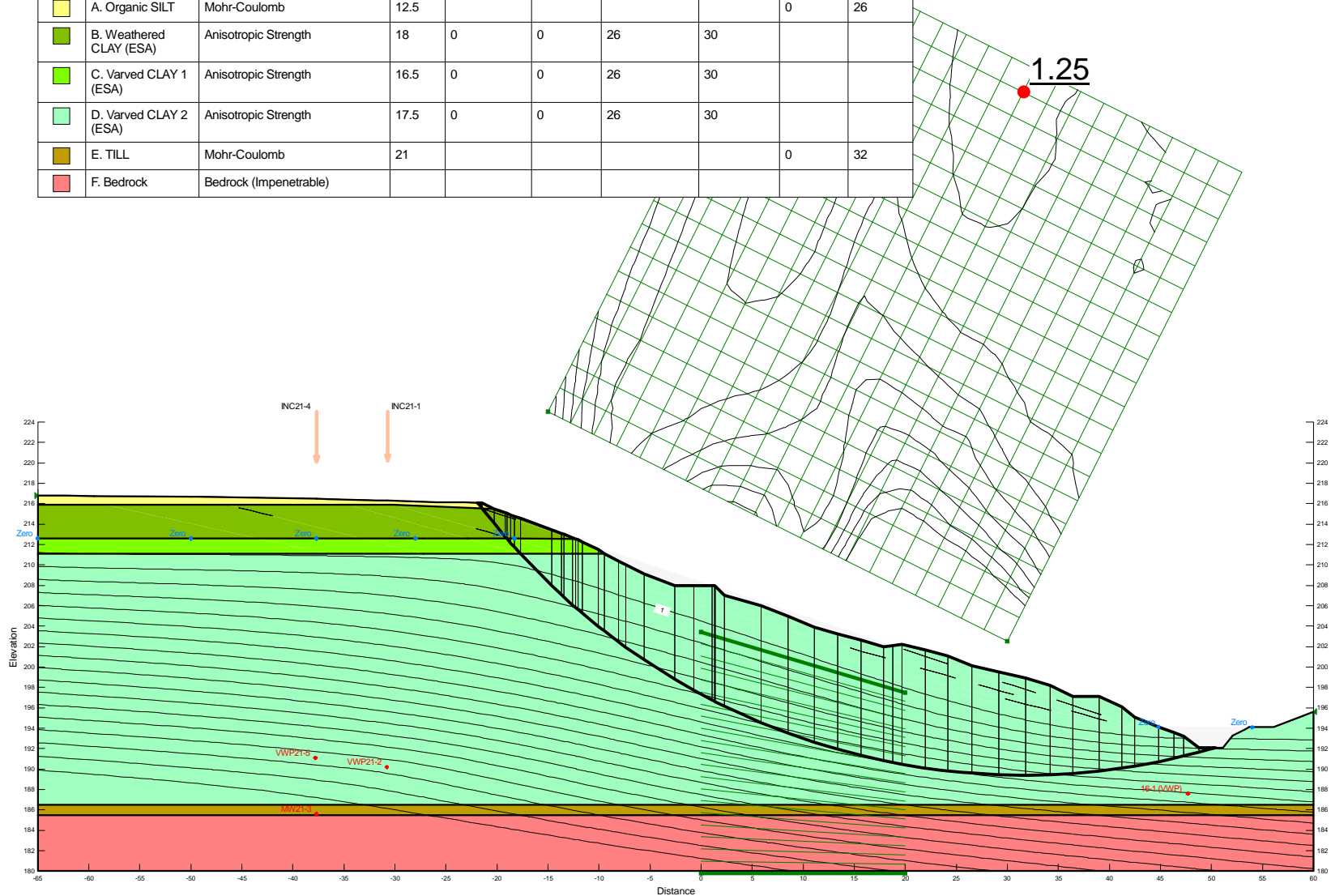


Project	
Calamity Creek	
Analysis	
06) 5% PWP Increase, static-drained conditions (upper slope only)	
Seismic Coefficient	Last Run
H: g, V: g	01/27/2022, 11:39:15 AM
Scale	1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-17.792177, 214.58806) m, Exit: (-0.86304181, 208) m
 Center: (-4.85, 222.8) m, Radius: 15.327617 m

Figure J6







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

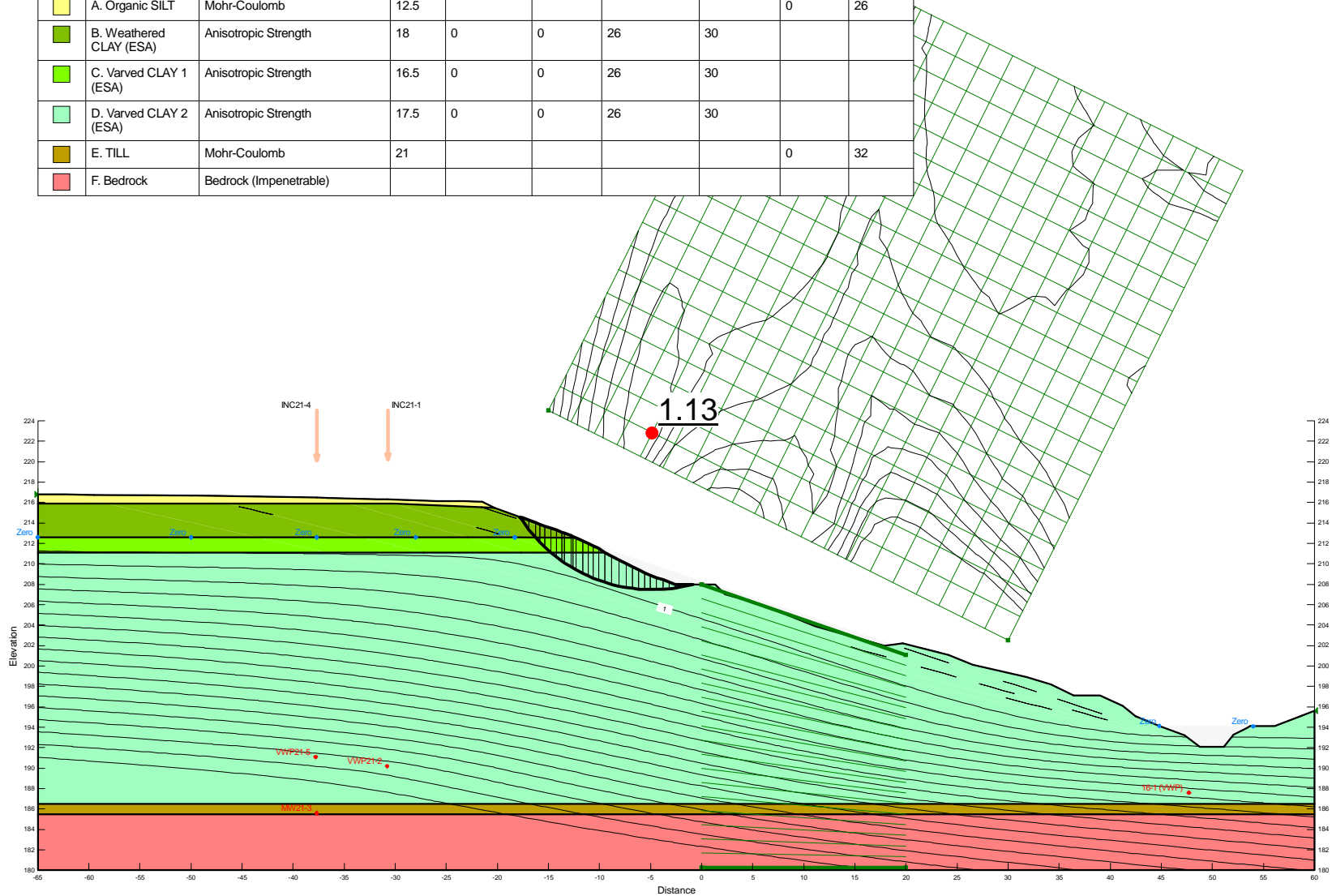


Project Calamity Creek		
Analysis 07) 5% PWP Increase, static-drained conditions (global slope)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:38:48 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-21.88264, 216.10376) m, Exit: (50.396024, 192.1) m
 Center: (31.6, 256.325) m, Radius: 66.918915 m

Figure J7

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							



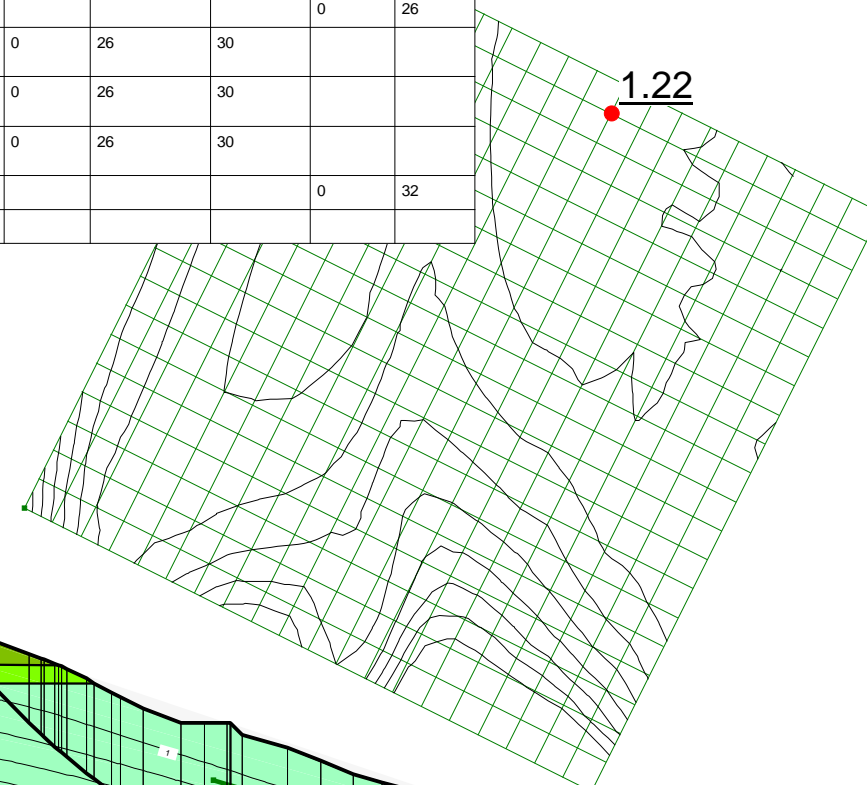
Project Calamity Creek		
Analysis 08) 10% PWP Increase, static-drained conditions (upper slope only)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:39:29 AM	Scale 1:600

Additional Details
Name: Section A-A
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 3.05 m
Entry: (-17.796067, 214.58948) m, Exit: (-0.85333741, 208) m
Center: (-4.85, 222.8) m, Radius: 15.330144 m

Figure J8

			0	26
0	26	30		
0	26	30		
0	26	30		
			0	32

1.22



Project	Calamity Creek
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Analysis

09) 10% PWP Increase, static-drained conditions (global slope)

Seismic Coefficient

H: g, V: g

Last Run

01/27/2022, 11:39:03 AM

Scale

1:600

Additional Details

Name: Section A-A

Comments: Slope Stability Assessment







Method: Morgenstern-Price, Half-Sine

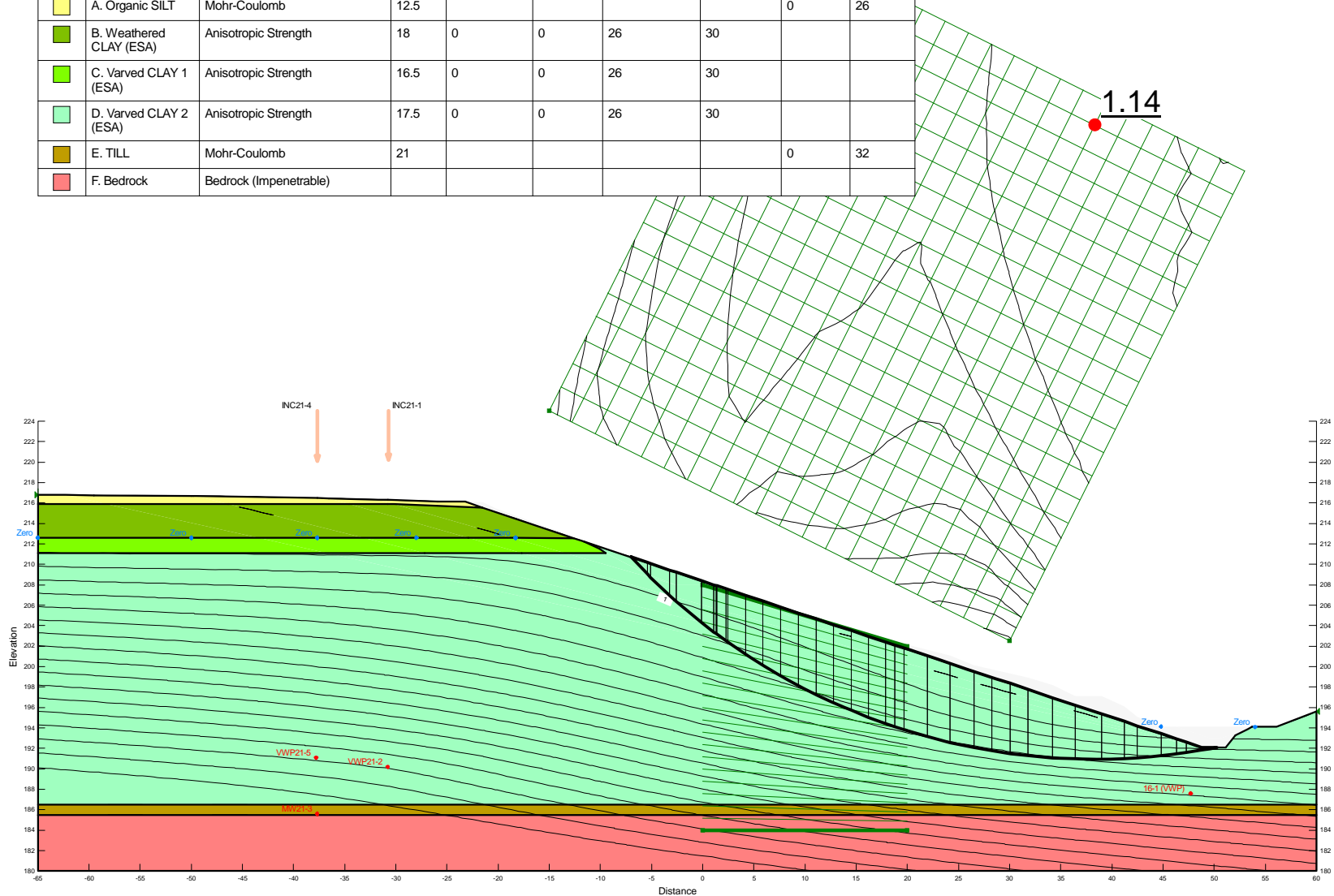
Minimum Slip Surface Depth: 3.05 m

Entry: (-21.883398, 216.10376) m, Exit: (50.398163, 192.1) m

Center: (31.6, 256.325) m, Radius: 66.919516 m

Figure J9

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

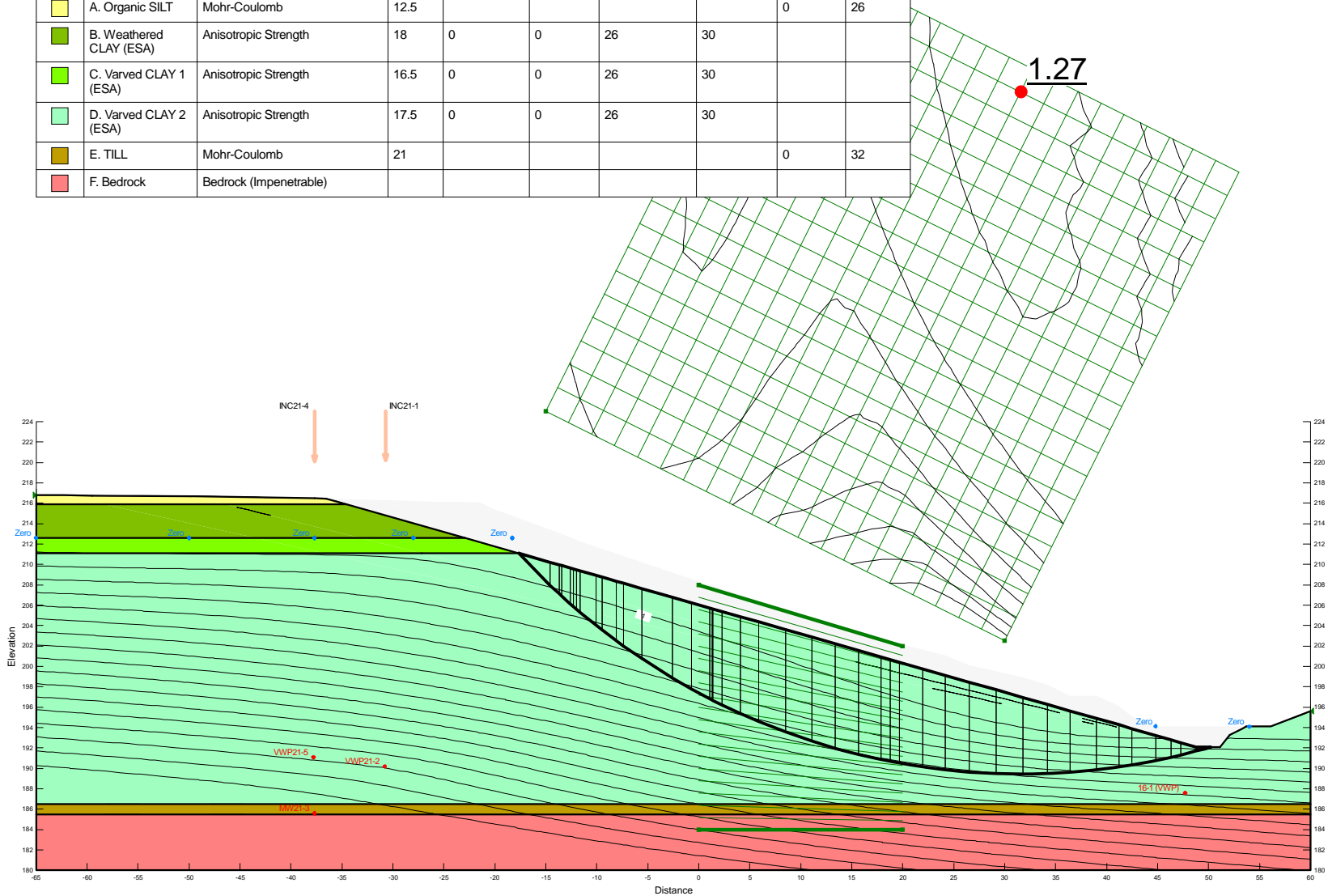


Project Calamity Creek		
Analysis 10) 3H:1V slope flattening		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:37:41 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-7.054381, 210.71813) m, Exit: (50.281744, 192.1) m
 Center: (38.35, 252.95) m, Radius: 62.008782 m

Figure J10







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
 	A. Organic SILT	Mohr-Coulomb	12.5					0	26
 	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
 	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
 	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
 	E. TILL	Mohr-Coulomb	21					0	32
 	F. Bedrock	Bedrock (Impenetrable)							

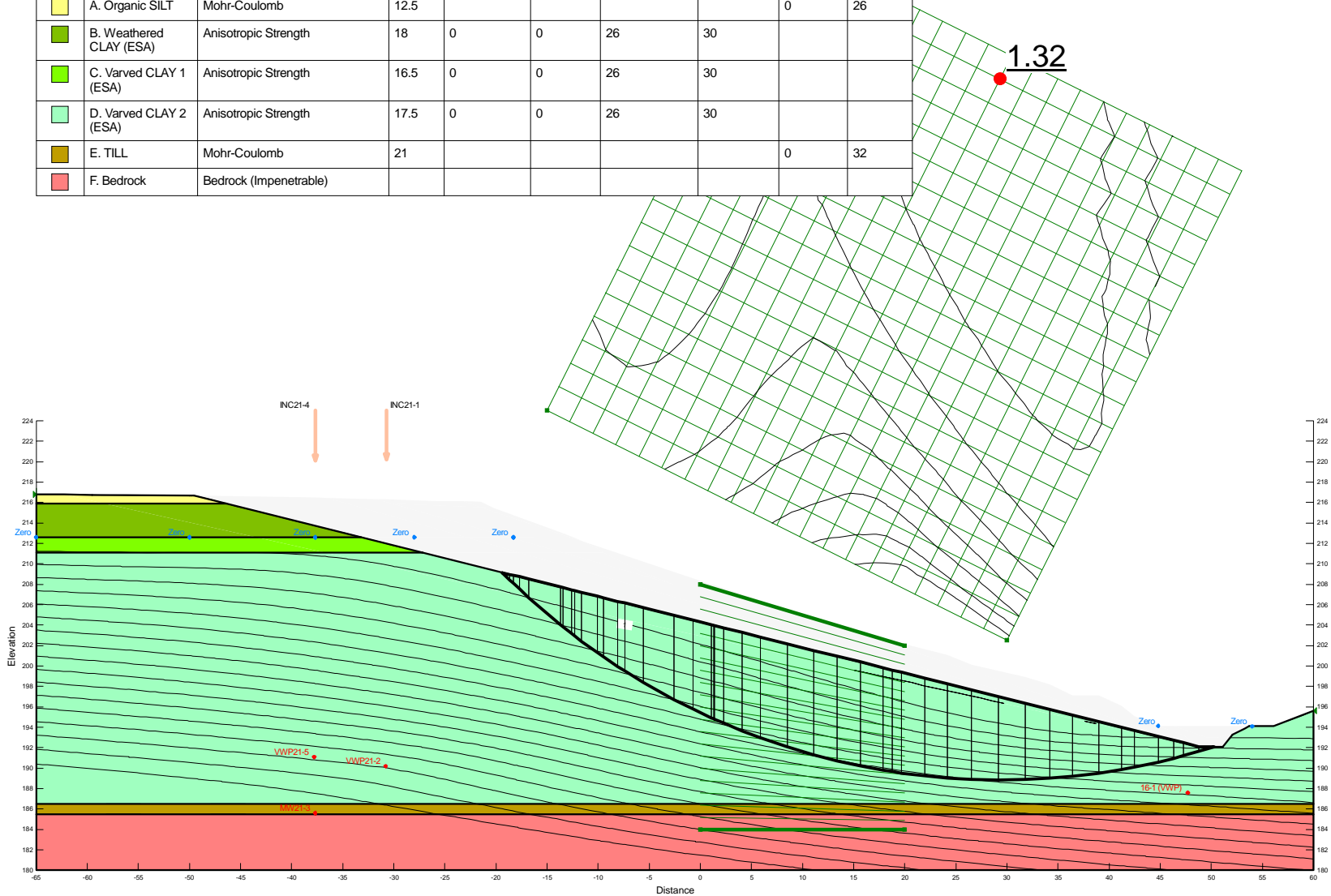


Project Calamity Creek		
Analysis 11) 3.5H:1V slope flattening		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:37:30 AM	Scale 1:600

Additional Details
Name: Section A-A
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-17.640077, 211.07316) m, Exit: (50.240364, 192.1) m
Center: (31.6, 256.325) m, Radius: 66.87536 m

Figure J11







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

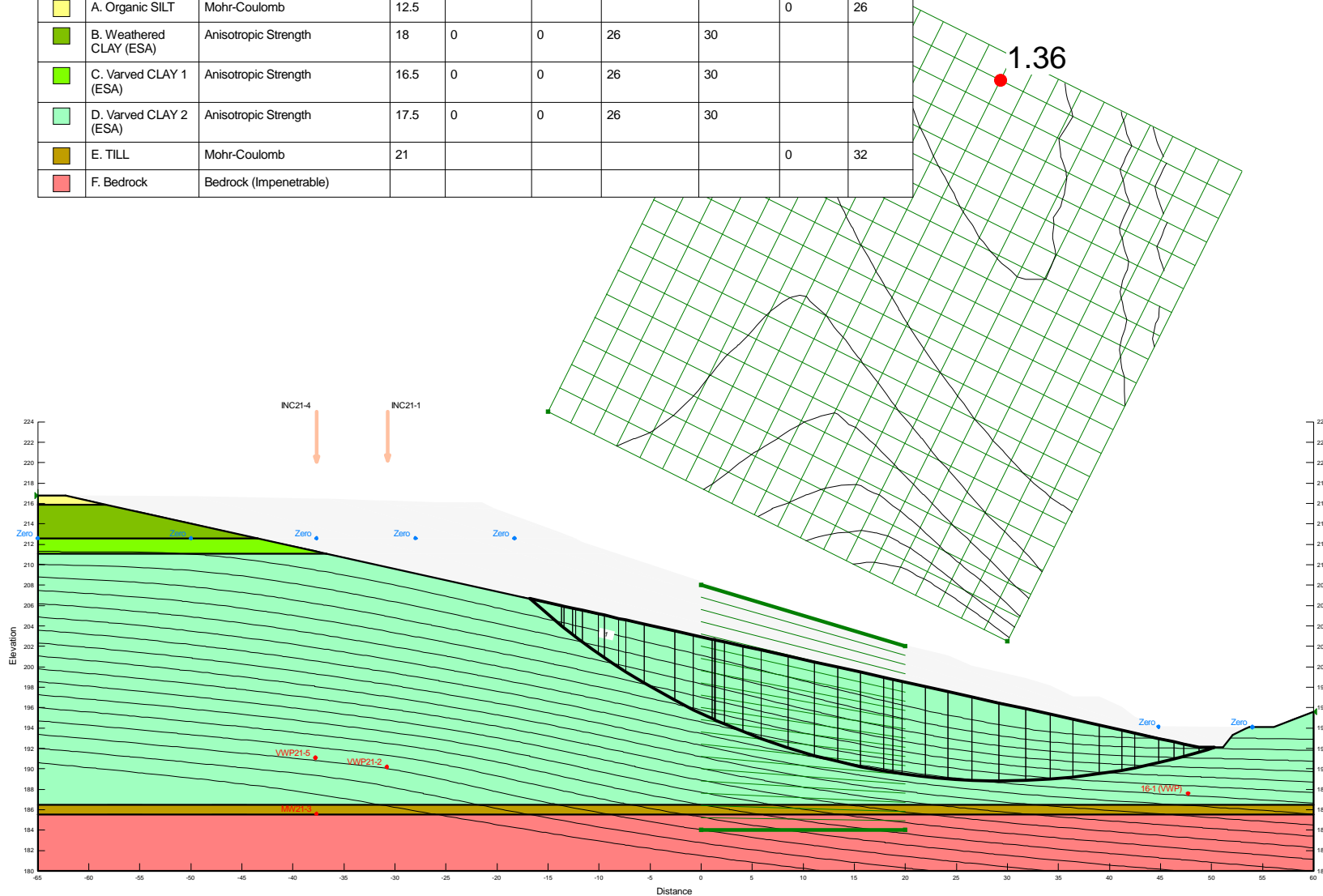


Project Calamity Creek		
Analysis 12) 4H:1V slope flattening		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:37:46 AM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-19.378893, 209.14472) m, Exit: (50.261295, 192.1) m
 Center: (29.35, 257.45) m, Radius: 68.614173 m

Figure J12









Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							

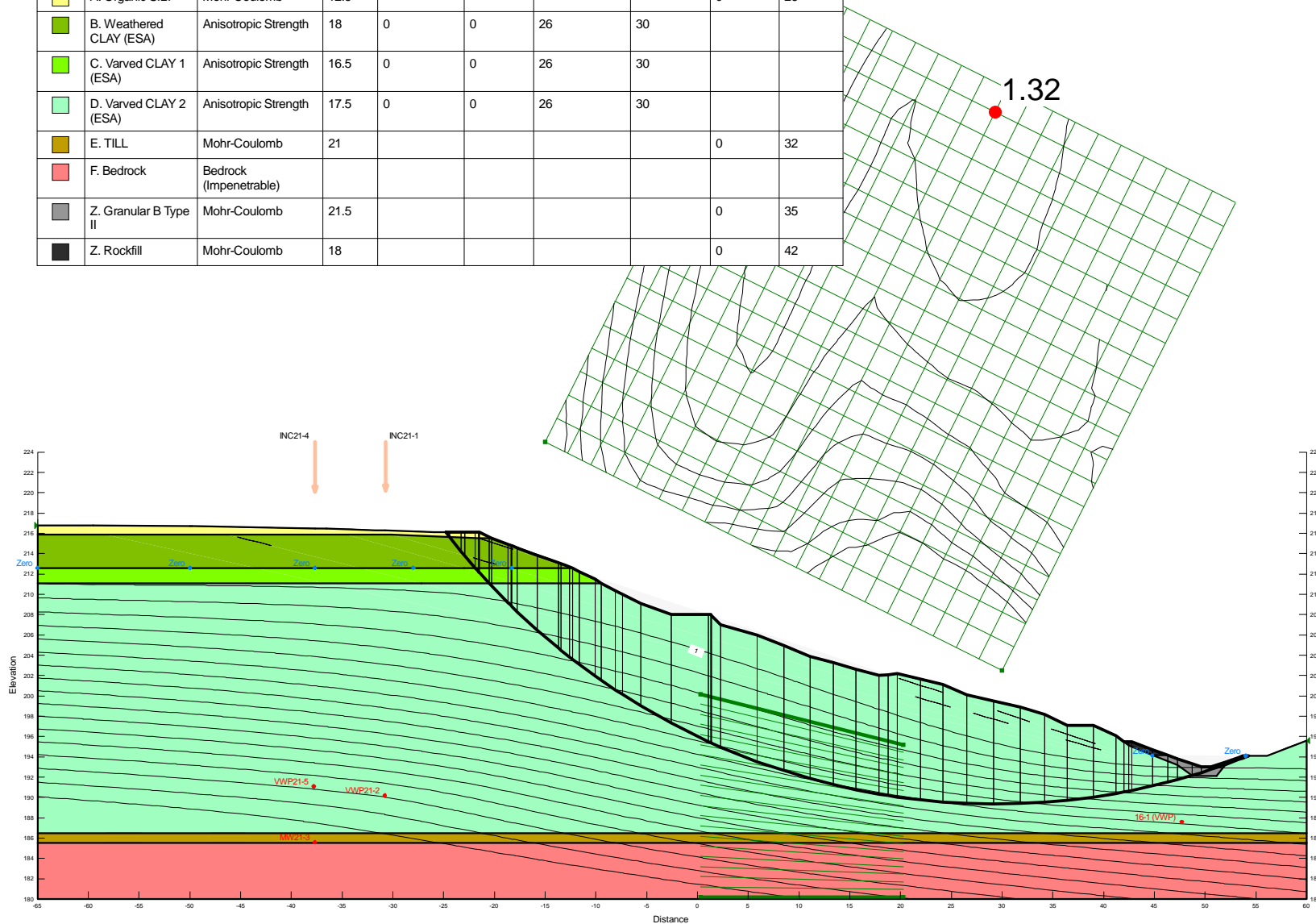


Project Calamity Creek		
Analysis 13) 4.5H:1V slope flattening		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 11:37:49 AM	Scale 1:600

Additional Details
Name: Section A-A
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-16.803781, 206.67862) m, Exit: (50.261295, 192.1) m
Center: (29.35, 257.45) m, Radius: 68.614173 m

Figure J13









Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							
	Z. Granular B Type II	Mohr-Coulomb	21.5					0	35
	Z. Rockfill	Mohr-Coulomb	18					0	42

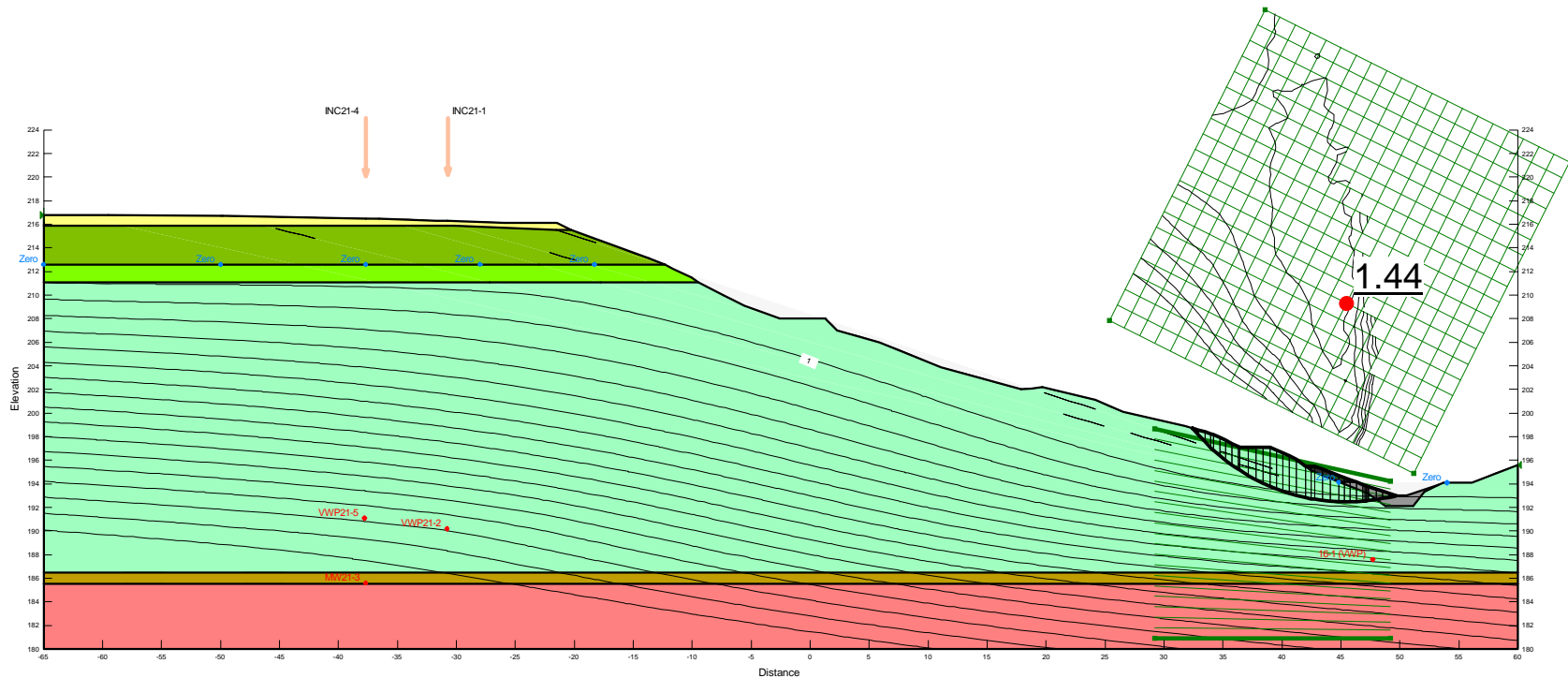


Project Calamity Creek		
Analysis 14) Butress (global slope)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 12:07:44 PM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-24.76943, 216.1321) m, Exit: (54.307144, 194.1) m
 Center: (29.35, 257.45) m, Radius: 68.088777 m

Figure J14









Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							
	Z. Granular B Type II	Mohr-Coulomb	21.5					0	35
	Z. Rockfill	Mohr-Coulomb	18					0	42

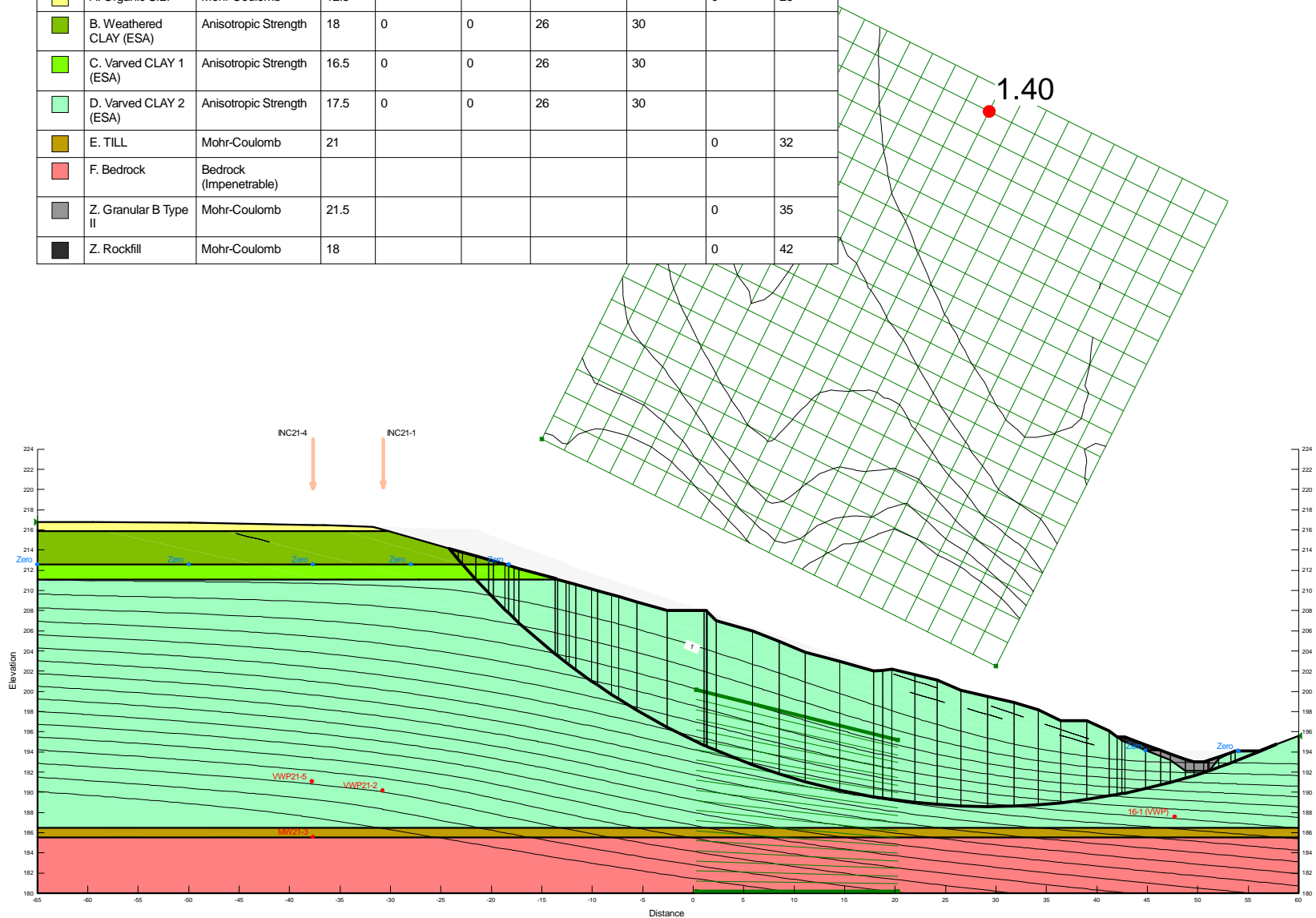


Project Calamity Creek		
Analysis 15) Butress (lower slope only)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 12:07:50 PM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (32.420695, 198.71896) m, Exit: (49.661853, 193) m
 Center: (45.50037, 209.30247) m, Radius: 16.825235 m

Figure J15

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	A. Organic SILT	Mohr-Coulomb	12.5					0	26
	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
	E. TILL	Mohr-Coulomb	21					0	32
	F. Bedrock	Bedrock (Impenetrable)							
	Z. Granular B Type II	Mohr-Coulomb	21.5					0	35
	Z. Rockfill	Mohr-Coulomb	18					0	42

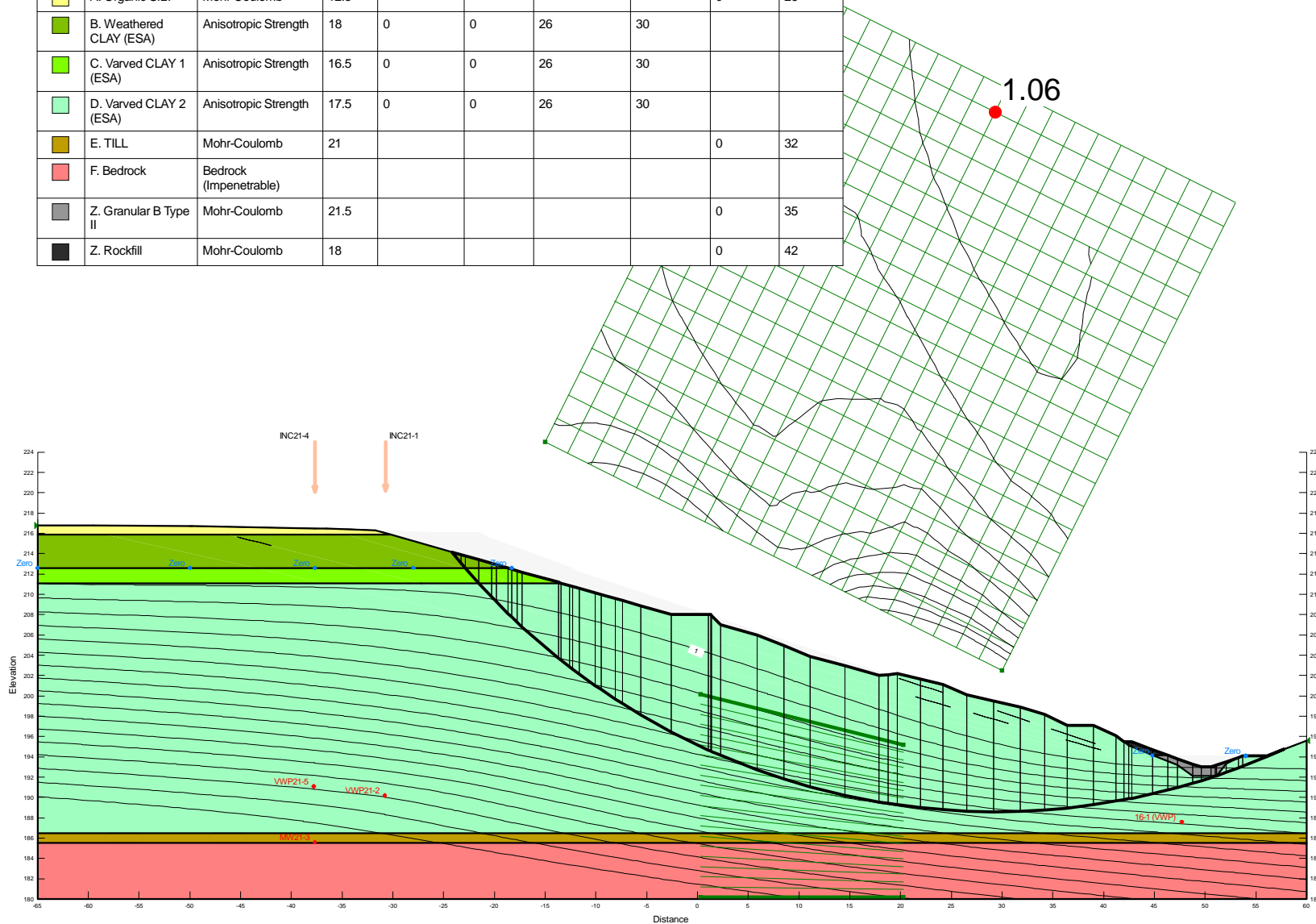


Project Calamity Creek		
Analysis 16) Butress & 3.5H:1V flattening at top (global slope)		
Seismic Coefficient H: g, V: g	Last Run 01/27/2022, 12:08:04 PM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-24.19263, 214.16932) m, Exit: (57.779218, 194.74585) m
 Center: (29.35, 257.45) m, Radius: 68.847879 m

Figure J16

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	C-Horizontal (kPa)	C-Vertical (kPa)	Phi-Horizontal (°)	Phi-Vertical (°)	Effective Cohesion (kPa)	Effective Friction Angle (°)
 	A. Organic SILT	Mohr-Coulomb	12.5					0	26
 	B. Weathered CLAY (ESA)	Anisotropic Strength	18	0	0	26	30		
 	C. Varved CLAY 1 (ESA)	Anisotropic Strength	16.5	0	0	26	30		
 	D. Varved CLAY 2 (ESA)	Anisotropic Strength	17.5	0	0	26	30		
 	E. TILL	Mohr-Coulomb	21					0	32
 	F. Bedrock	Bedrock (Impenetrable)							
 	Z. Granular B Type II	Mohr-Coulomb	21.5					0	35
 	Z. Rockfill	Mohr-Coulomb	18					0	42



Project Calamity Creek		
Analysis 17) Butress & 3.5H:1V flattening at top with 475 yr earthquake		
Seismic Coefficient H: 0.081g, V: g	Last Run 01/27/2022, 12:08:20 PM	Scale 1:600

Additional Details
 Name: Section A-A
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 3.05 m
 Entry: (-24.19263, 214.16932) m, Exit: (57.779218, 194.74585) m
 Center: (29.35, 257.45) m, Radius: 68.847879 m

Figure J17